

TERRA

THE NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY

VOL. 23, NO. 5 • MAY/JUNE 1985



FROM THE DIRECTOR



Dr. Craig C. Black

On May 3 the Alex Deutsch Gallery featuring Gemstones and Their Origins will open to the public. This is the second major permanent exhibition to open at the museum in the past twelve months, the other being Seaver Hall—The Growth of the Nation: 1815 to 1865, which opened last May.

These two new galleries add significantly to the museum's overall education and exhibition programs. Neither would have been possible without the dedication of private donors to the goals of the museum. Both Alex Deutsch and the Seaver family are long-time supporters of the museum, and their generous contributions have done much to bring new and improved programs to the people of Los Angeles; we are all in their debt.

Planning is now going forward to ensure that the momentum developed over the past year continues. To that end, a joint Trustee/Curatorial Task Force has been at work over the last six months developing a comprehensive five-year plan to strengthen all aspects of the museum, with special emphasis on exhibition and education programs.

It is our intention to work as quickly as possible to refine and adopt a blueprint for the future so that we can substantially expand our ability to delight and educate our public prior to the museum's seventy-fifth anniversary in 1988. I also believe that by carrying out such a bold, imaginative plan, our museum will firmly establish itself, both nationally and internationally, in the forefront of natural science and history institutions.

In the coming months I will be reporting to you the specific details of our efforts to make our museum an even stronger cultural and community asset and letting you know how you, just as Alex Deutsch and the Seaver family, can

be a part of a new and exciting enterprise that will benefit our entire community. I look forward to our joining forces in the near future to make our museum an even better and more exciting place to visit.

CURATORS & COLLECTIONS

NSF Grant Award to Invertebrate Paleontology

The National Science Foundation has awarded Dr. Edward Wilson, Curator of Invertebrate Paleontology, a grant to study the fossil coral fauna of the central Andes. The corals are of Early Permian age (about 270 million years old) and have been uplifted from their original sea-level position to an altitude of more than thirteen thousand feet. Mr. John Pandolfi, another coral specialist and a graduate student at the University of California at Davis, will accompany Dr. Wilson to South America as a field assistant. They will spend a month in Bolivia in 1985 and six weeks in Peru in 1986 collecting specimens and studying their geological setting. This work is expected to shed light on the geographic position of South America and the circulation of ocean currents during the Early Permian as well as determining the composition of the coral fauna.

Society of Vertebrate Paleontology Offices Move to Museum

The national offices of the Society of Vertebrate Paleontology have recently been moved to the museum. Dr. David P. Whistler, curator of Vertebrate Paleontology, is the society's secretary-treasurer, and Dr. John M. Harris, Chief Curator, Division of Earth Sciences, is the editor of the society's *News Bulletin*. Miss Jill Papac is the managing editor of the *Bulletin* and maintains the society's files.

BOOK REVIEW

The Heirloom Gardener by Carolyn Jabs

Sierra Club Books, San Francisco 1984
310 pp. Paper \$9.95, cloth \$17.95.

Monoculture, or the cultivation of one plant type to the exclusion of others, has replaced the plethora of plant varieties that used to characterize our gardens and farms. For example, in the Middle Ages there were sixty varieties of basil; now there are probably fewer than five cultivars in circulation. In 1900 there were 8,000 apple varieties in the United

(Continued on page 31)

TERRA

THE MEMBERS' MAGAZINE
OF THE NATURAL HISTORY MUSEUM
OF LOS ANGELES COUNTY
AND THE PAGE MUSEUM
OF LA BREA DISCOVERIES

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A freshly exposed pocket of amethyst
in Rio Grande do Sul, Brazil. Photo by
Amos Schliack.

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GEMSTONES AND THEIR ORIGINS

by PETER C. KELLER and
ANTHONY R. KAMPF

The earth is a dynamic laboratory. For more than four and a half billion years, geologic forces have been at work, reshaping the earth's surface and transforming the minerals within. Minerals are continually being created and destroyed in a never-ending cycle. Today we are aware of more than three thousand different species of mineral, each with its unique characteristics. Yet of these only about seventy are grouped into the very special class we call gemstones.

Historically, gemstones have been used principally for personal adornment. This usage has determined their necessary attributes: they must be beautiful, durable, and rare. A gemstone's beauty enhances the appearance of its wearer. A gemstone must be durable to withstand the rigors of wear and to be passed from generation to generation. And for a gemstone to be valued and sought-after, it must be rare and difficult to obtain.

Most people can appreciate the monetary value of a gemstone and can admire its beauty, particularly when it is mounted in a piece of jewelry. Few, however, are as aware of the natural and human history of gemstones—what they tell us about the geologic history of the earth and the lives of the people who depend on recovering them from the earth for their existence. These are the fascinating stories that we will touch briefly upon here and that can be appreciated more fully in the Natural His-

*In gemstones the whole
majesty of Nature is encom-
passed in minute space,
and a single one suffices to
demonstrate the excellence
of creation.*

—Pliny the Elder

tory Museum's newest exhibit gallery, Gemstones and Their Origins.

On the earth's surface, rocks crumble under the destructive forces of the atmosphere, particularly rain. Some minerals break into smaller pieces, while others dissolve. Over millions of years this weathering process may be responsible for eroding entire mountain ranges and carrying away their minerals. But some minerals are not as susceptible to the ravages of nature. They are too hard or tough to be mechanically broken down and too insoluble to be dissolved. Among these are certain gemstones such as ruby, sapphire, topaz, jade, and diamond. These gemstones are freed from the surrounding rock and transported by river currents and wave action. The ability of the moving water to carry these large mineral grains depends upon the water's speed. In places where the water slows, the gemstones are dropped. Here are formed alluvial (river) deposits of "gem gravel," in which the gemstones are often far more concentrated than they were in the rock from which they

originated.

Gem-bearing alluvial deposits are found throughout the world. The beach sands on either side of the mouth of the Orange River in South Africa and Namibia are among the richest alluvial diamond deposits in the world. Many of the world's finest rubies have come from the alluvial deposits of Mogok, Burma. But the most prolific of all alluvial deposits are on the tiny island of Sri Lanka (formerly Ceylon) off the southeastern tip of India.

Sri Lanka has rightly been nicknamed the "Gem Island," for here is found an unbelievable variety of gems. The gem gravels, known locally as *illam*, have yielded untold quantities of sapphire, chrysoberyl, spinel, and at least a dozen lesser known gem species. The mining methods on Sri Lanka have changed little since Marco Polo's visit to the island in the thirteenth century. Men dredge the rivers for gems using hand tools. More commonly, however, vertical pits are dug through many feet of sediments to reach the older, buried gem gravel. The gravel is carried from the pits in large conical baskets, which are then agitated in water to remove the lighter mud. Finally, the gemstones are carefully hand-sorted from the remaining gravel. The rough gemstones are taken to cities such as Kandy and Colombo to be cut by local artisans. Gem dealers from all over the world visit Sri Lanka's gem centers in search of gems for their trade.

In Sri Lanka, hand-operated hoists are often used to lift buried gem gravel (known as illam) to the surface. Here, a vertical shaft has been dug through many feet of overburden to reach the illam containing sapphire, cats-eye chrysoberyl, spinel, and many lesser known gems. Photo by P. Horree.



Water plays an entirely different role in the formation of gemstone deposits when it dissolves minerals. We seldom think of ordinary water as being effective in dissolving rock. But given sufficient time, particularly if the water has become acidic or basic, or if it has been heated, it can readily dissolve many kinds of minerals. When water carrying the elements from earlier dissolved minerals encounters proper conditions underground or other minerals with which it can react, it will deposit new minerals in seams and cavities. Gemstones that may be formed in this way include turquoise, malachite, amethyst, rhodochrosite—and opal, the most valued and sought-after of these gems.

In arid regions, where rainfall is limited to seasonal showers, the conditions are ideal for the formation of opal deposits. During isolated showers, rainwater percolates down through permeable rocks rich in silica (silicon dioxide) such as certain kinds of volcanic ash or tuff. The water dissolves silica from these

rocks and carries it down to the water table, where it is concentrated. The water table is high during the rainy season, and the water fills open spaces formed by fractures, decomposed organic matter, or dissolved minerals. During the dry season, some of the water evaporates, making the remainder rich in silica; finally opal, a form of solid silica containing water, precipitates in the open spaces in the rock.

Opal actually consists of billions of submicroscopic particles of silica stacked together. The play of color that characterizes precious opal results from the interplay of light with the stacking of particles. It can only occur when the silica particles are all spheres of the same size that have settled in a very orderly pattern. Most opal is made of irregular particles in a disorderly array and does not show play of color.

The finest precious opal in the world is mined in the arid, desolate regions of eastern Australia. Best known of the deposits are those at Andamooka, Coober

Pedy, and Mintabie in South Australia; Lightning Ridge in New South Wales; and the many smaller deposits in Queensland. The mining usually involves sinking a vertical shaft to a depth of ten to sixty feet and then driving horizontal tunnels until an opal seam is found. In the past, the shafts and tunnels were dug entirely with hand tools. Today, large boring machines produce smooth, round holes several feet in diameter. When an opal seam is encountered, the mining reverts to hand methods so that the fragile opal can be recovered intact.

Very hot water vapors escaping from magmas deep in the earth's crust are known as hydrothermal fluids (from *hydro* meaning water, and *thermal* meaning hot). These fluids often carry rare elements, such as fluorine and beryllium, away from the magma. The fluids flow through fractures in the surrounding rocks and combine with near-surface water, picking up additional elements.

(Continued on page 9)



The striking play-of-color against a dark background sets Australian black opal apart as the most desirable variety of this gem. Photo by Harold and Erica Van Pelt.

In the opal fields of Australia, large drilling rigs bore cylindrical shafts down to the opal-bearing strata. Photo by Rick Shaw.





This superb 1759-carat emerald crystal from Muzo, Colombia, is owned by the Banco de la Republica in Bogotá, Colombia. Photo by Harold and Erica Van Pelt.

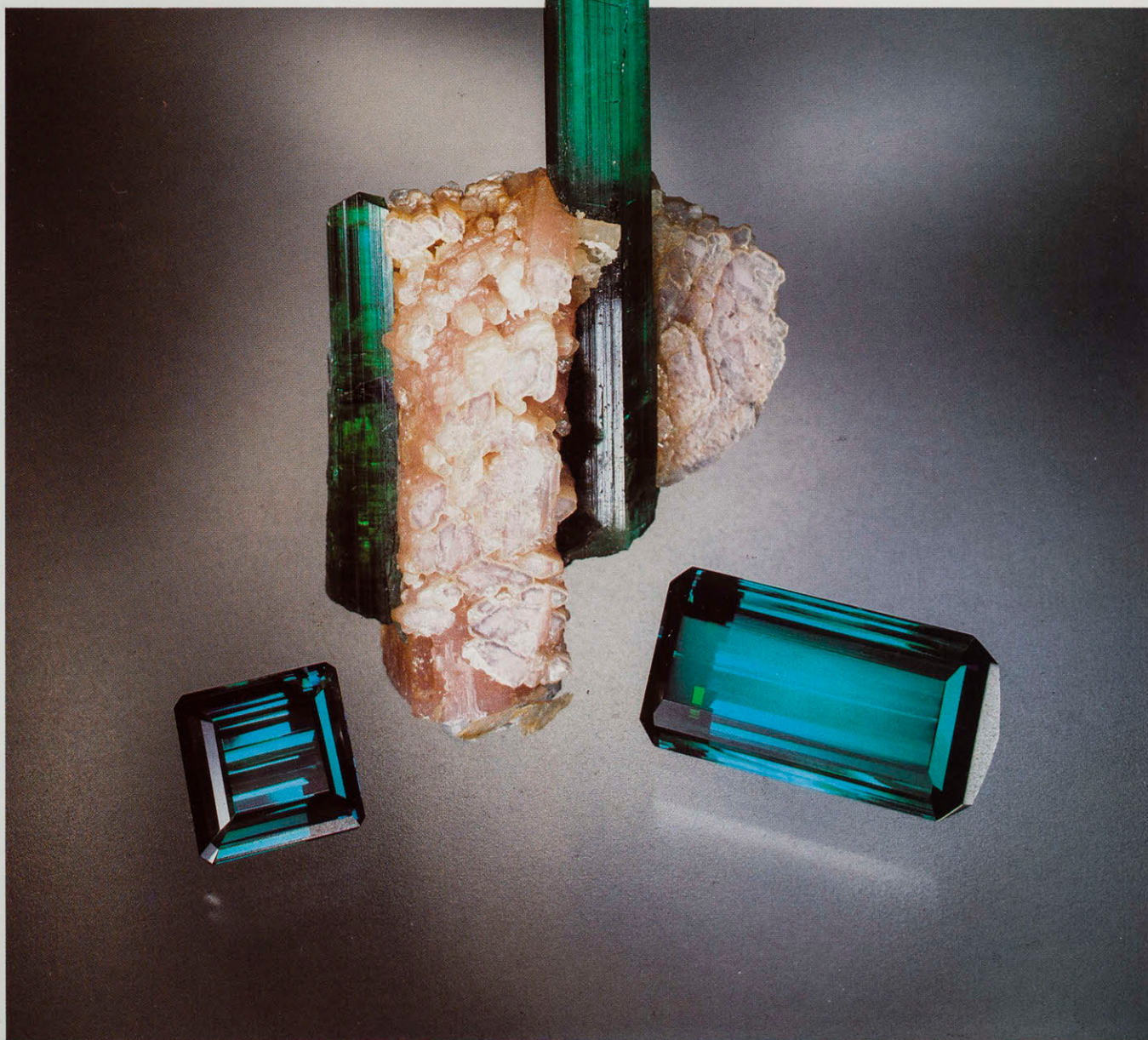
Independent miners (known as guaqueros) crowd the Itoco River near Muzo, Colombia. They search for emeralds overlooked by the more sophisticated mining operations on the hillsides above. Photo by Peter C. Keller.



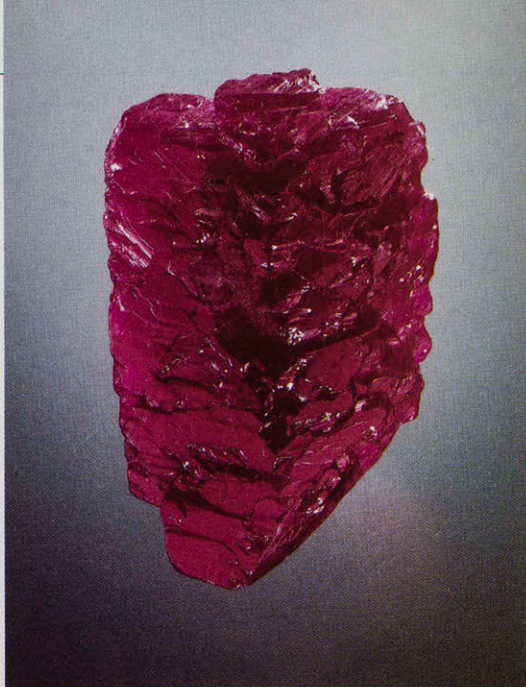
*Much of the pegmatite mining in Brazil's Minas Gerais is done with a pick and shovel. More modern mines use power tools.
Photo by Peter C. Keller.*



Tourmaline, one of the most popular gems found in Brazilian pegmatite deposits, may occur in many colors. The blue variety is known as indicolite. The faceted stones, seen here, weigh 67.9 and 21.9 carats. Photo by Harold and Erica Van Pelt.



*This 196-carat Burmese ruby crystal from the museum's Hixon Collection is one of the finest uncut examples of ruby ever placed on public display.
Photo by Harold and Erica Van Pelt.*



More than 70 percent of the world's fine rubies now come from near Chanthaburi, Thailand. Circular rattan baskets serve as the principal implement for recovering the rubies from alluvial gravel. Photo by Peter C. Keller.



The resulting solutions eventually cool and deposit veins of minerals in the fractures. Under the right conditions, and if the proper elements are present, the veins may contain gemstones such as topaz, amethyst, benitoite, and emerald.

The most important of the hydrothermal gemstone deposits is the emerald mining district at Muzo, Colombia. This deposit in the Andes Mountains of central Colombia, sixty miles north of the capital city of Bogotá, has yielded the finest emeralds in the world for more than four hundred years. At Muzo, the emeralds are found in veins of white calcite that cut through black carbonaceous shale. The violent history of emerald mining in the region dates to the sixteenth century, when thousands of local Indians met their deaths at the hands of Spanish conquerors. But even as recently as 1972, feuds between independent miners, known as *guaqueros*, resulted in more than nine hundred deaths and forced the mines to close. Today emerald mining is booming in the area with private companies working the mines and as many as ten thousand *guaqueros* scouring the stream beds below for overlooked gems.

Pegmatites, granitelike rocks with very large crystals, produce more kinds of gemstone than any other type of deposit. A pegmatite forms when the water-rich portion of a molten granite is squeezed into a fracture in the solid surrounding rock. As the pegmatite liquid cools in the fracture, it begins to solidify at the outer walls first, then toward the center. The liquid changes in composition, and the minerals forming from it also change, creating layers (or zones) of minerals. The last fluid remaining in cavities in the center of the pegmatite is very hot water containing rare elements such as beryllium, boron, and lithium. Gemstone crystals may form from this fluid, creating gem pockets.

San Diego County, California, is well known for its gem-rich pegmatites. In the early part of this century, tons of tourmaline were mined here and most were shipped to China for carving. Since World War II, the eastern portion of the Brazilian state of Minas Gerais (meaning "general mines") has eclipsed the rest of the world in the production of gemstones from pegmatite deposits. Nearly all the gemstone mining in Brazil is done by independent prospectors known as *garimpeiros*. The miners work in small groups and live solely off the profits of what they find.

The natural history of gemstones provides a fascinating story that transcends man's use of these natural artifacts for adornment. Gemstones are an important key to understanding the earth.

Water plays an essential role in the formation of all the deposits considered thus far. Such is not the case for gemstones such as ruby, sapphire, moonstone, and zircon, which grow directly from molten rock while it is still deep in the earth. The magma must cool slowly at first, allowing the gemstone crystals to grow. Then, while most of the magma is still liquid, it rushes upward, carrying the gem crystals with it. It cools and solidifies in fractures near the surface or as volcanic lavas on the surface. Most often the magma is of a type known as alkali basalt.

In tropical climates alkali basalts decompose rapidly, leaving the gem crystals behind to accumulate in alluvial gravels. Southeastern Thailand now produces over 70 percent of the world's fine rubies from decomposing basalts or the resulting alluvial gravels. The town of Chanthaburi is the center of Thailand's ruby mining. Here huge water cannons blast the rubies from the decomposed basalt. The slurry of rock fragments in water is directed over riffle tables where the rubies are recovered. This hydraulic mining method is reminiscent of that used to recover gold from alluvial gravels during California's Gold Rush. As at Muzo, Colombia, an entire society lives off the gemstones missed by the large mining enterprises. The principal tool employed by the Thai miners is a circular rattan basket, used much like a gold pan, which concentrates the ruby-bearing gravel.

Many gemstones grow from fluids—in particular, water and molten rock. There are others that form in solid rock by a process known as *metamorphism*. This occurs when the temperature or pressure rises so high that the original minerals in the rock can no longer exist. They gradually change without melting to new minerals that can exist under the new conditions. Metamorphism commonly takes millions of years and actually may involve a small amount of

water or limited melting. Most metamorphic gemstones result from "regional metamorphism" (metamorphism that occurs over a wide area). Regional metamorphism can be subdivided into high-temperature and high-pressure varieties.

High-temperature regional metamorphism typically occurs when two continents collide. On the earth's surface a vast mountain range forms, such as the Himalayas where India once collided with the rest of Asia. But deep below the mountain range, where both temperature and pressure become extreme, metamorphism creates new minerals, including ruby, emerald, garnet, chrysoberyl, and nephrite jade.

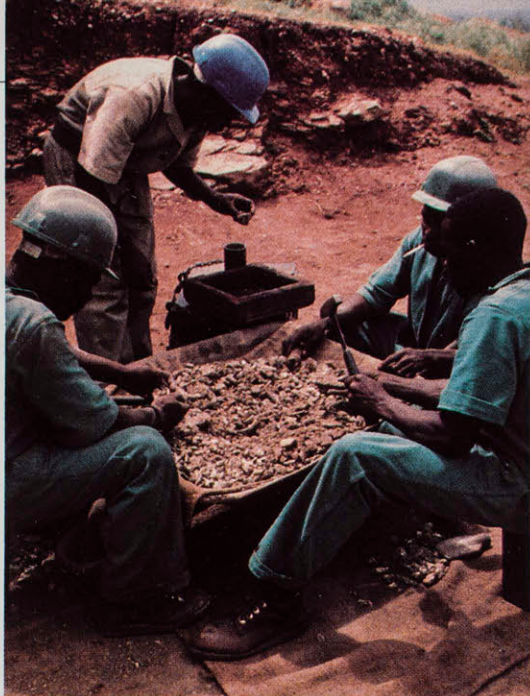
A vast area of regionally metamorphosed rocks extends down the eastern side of Africa, from Sudan and Ethiopia in the north to Mozambique in the south. Recent discoveries in Tanzania and Kenya have shown this to be one of the world's richest gemstone regions. To date, the metamorphic rocks of East Africa have yielded gem-quality tanzanite, tsavorite, emerald, ruby, and sapphire, as well as many less important gemstones.

Most mining in the region is conducted on the surface by open pit methods. Decomposed (weathered) metamorphic rocks are soft and easy to mine. The gemstones, much more durable than the rock, are recovered by screening. In the hard, unweathered metamorphic rocks, heavy equipment must be used. Rock is removed until a gem-bearing layer, locally called a *reef*, is encountered. Mining of the reef then proceeds more carefully by hand.

The high-pressure (low-temperature) type of regional metamorphism (referred to as "blueschist metamorphism" by geologists), commonly occurs where the ocean floor slides under the edge of a continent. As it moves down, the ocean crust is subjected to great pressure and undergoes metamorphism. Blocks of the ocean crust are broken off and pushed back up to the surface of the earth before they can become too hot. The minerals formed under these conditions are quite different from those formed during high-temperature regional metamorphism. Jadeite jade is the only important gemstone formed by this process.

The world's most important deposits of gem-quality jadeite are found in northern Burma. Here veins of jadeite intermixed with albite feldspar occur on a plateau about 270 miles north of Man-

(Continued on page 12)



Sorting gemstones from the rock in which they are found must usually be done by hand. Here, miners at the Lualenyi mine in Kenya sort tsavorite garnet. Photo courtesy of the Gem Institute of America.

The rare green variety of garnet known as tsavorite is found only in East Africa. Uncut fragments of tsavorite are shown with a faceted gem. Photo by Harold and Erica Van Pelt.



The diamond crystal from which this flawless 5.07-carat gem was cut formed within the earth at a depth greater than ninety miles. Stone courtesy of Jack and Elaine Greenspan. Photo by Harold and Erica Van Pelt.



The mining of kimberlite diamond ore in Africa usually takes place underground and is highly mechanized. Miners use drills to bore into the rock prior to setting explosive charges. The ore recovered by blasting is transported to the surface where it is crushed to free the diamonds. Photograph courtesy of DeBeers Consolidated Mines Ltd.



dalay. The best known of the deposits is at Tawmaw. The jadeite was first found and recovered as stream-worn boulders from the riverbeds in the region. The source of the jadeite as veins in hard rock was found later, but because of the extreme toughness of the jadeite, much of the mining still takes place in the riverbeds. The miners must often divert the river and use pumps to keep the water out of their pits. Much of the jadeite is sent to Rangoon, where it is sold at government-run auctions. From there it commonly finds its way to Hong Kong, where it is carved for the international market.

All the gemstones that we have considered thus far form in the earth's crust—the planet's thin outer shell. Two important gemstones, peridot and diamond, form in the very thick layer of rock, called the mantle, between the crust of the earth and its metallic core. The mantle makes up 83 percent of our planet's volume, but rarely do pieces of it reach the surface.

Compressive forces acting on areas where the earth's crust is thin may produce "thrust sheets," where a slice of the earth's crust and portions of the underlying mantle are forced over the top of the adjoining crust. Subsequent erosion will in time reveal the overthrust mantle rock, but only samples of the uppermost part of the mantle, from depths between six and twenty miles, is exposed in this way. One of the most important constituents of this part of the mantle is forsterite olivine, which is known as peridot when it is of gem quality.

The finest peridot in the world comes from Zabbarjad (formerly Saint John's Island), a tiny island in the Red Sea that is situated on a thrust sheet. Despite the desolate nature of this island and its lack of fresh water, peridot has drawn men here for over one thousand years. Small pits and tunnels, some hundreds of years old, dot the island. But peridot has not been mined commercially on the island since before World War II. The political instability of the region and the availability of peridot from more accessible and hospitable places in the world continue to discourage modern mining undertakings there.

Today most of the world's peridot comes from mantle-derived inclusions in a single alkali basalt deposit on the San Carlos Indian Reservation in Gila County, Arizona. Alkali basalts are dark volcanic rocks that are the result of the

More often than not gems are mined today using techniques first developed hundreds of years ago.

partial melting of rocks in the mantle at depths between twenty and sixty miles. The molten rock rises rapidly and explosively to the earth's surface, where it erupts as a volcano. Often alkali basalts carry with them solid fragments of mantle rocks containing abundant forsterite olivine. Rarely this olivine occurs as large, transparent nodules of peridot.

The Apache Indians have been mining peridot from Peridot Mesa on the San Carlos Reservation for more than a century. Mining is limited to hand tools because dynamite would shatter the brittle peridot crystals. The mesa is dotted with numerous small pits where Indians, using hammers and chisels, free the peridot from the enclosing basalt.

Diamonds reach the earth's surface in turbulent, volcanic eruptions that originate in the mantle at depths between ninety and two hundred miles. No eruption of this type has occurred in recorded history. Nevertheless, geologic clues provide a good picture of their nature.

Diamond-bearing deposits are most commonly composed of a rare rock, kimberlite, which contains broken and somewhat rounded fragments of solid rock from both the mantle and the crust. The deposits are in the form of narrow vertical tubes or "pipes," which flare out into a cone shape near the surface and may be as much as several thousand feet across.

Although the origin of kimberlite deposits is still open to debate, most scientists believe that they originated from gases and liquids under high pressure in the mantle. These highly fluid magmas rose at great speed along weaknesses in the crust, violently tumbling pieces of rocks they picked up along the way, until they burst explosively through the surface. Diamonds are often found as single crystals embedded in the volcanic kimberlite matrix.

The study of kimberlites as sources of diamond is relatively recent. Until 1870, diamond had only been found in alluvial deposits. In that year, the first of several diamond pipes was discovered near the town of Kimberly in South Africa (hence

the name kimberlite). Since that time kimberlite deposits have been found in many parts of the world, but South Africa is the most important producer of gem-quality diamonds.

The initial discovery at Kimberly started a diamond rush. Thousands of individuals staked small claims on the Kimberly pipe. Miners dug by hand at different rates. Each had his own rope-way to hoist rock to the surface. Those who dug more slowly soon found their claims situated precariously above the surrounding claims. Mining became very inefficient and dangerous. In 1889 the efforts of Cecil Rhodes culminated in the formation of DeBeers Consolidated Mines Ltd., uniting all the claims. Today DeBeers operates most of the mines in South Africa and controls the distribution of 85 percent of the world's diamonds.

In these few pages we have probed more than one hundred miles into the earth. We have examined the geologic processes that give rise to the wonderful diversity of the most coveted of minerals—the gemstones. Our journey has also taken us around the world for a brief glimpse at some of the most important of the gem-producing areas and the methods used to recover these much sought-after treasures of nature. More often than not these gems are mined today using techniques first developed hundreds of years ago.

The natural history of gemstones provides a fascinating story that transcends man's use of these natural artifacts for adornment. Gemstones can be an important key to our understanding of the earth. An imperfection in a diamond, undesirable from aesthetic and economic standpoints, actually provides one of the few clues man will ever have to the nature of the earth's inaccessible mantle.

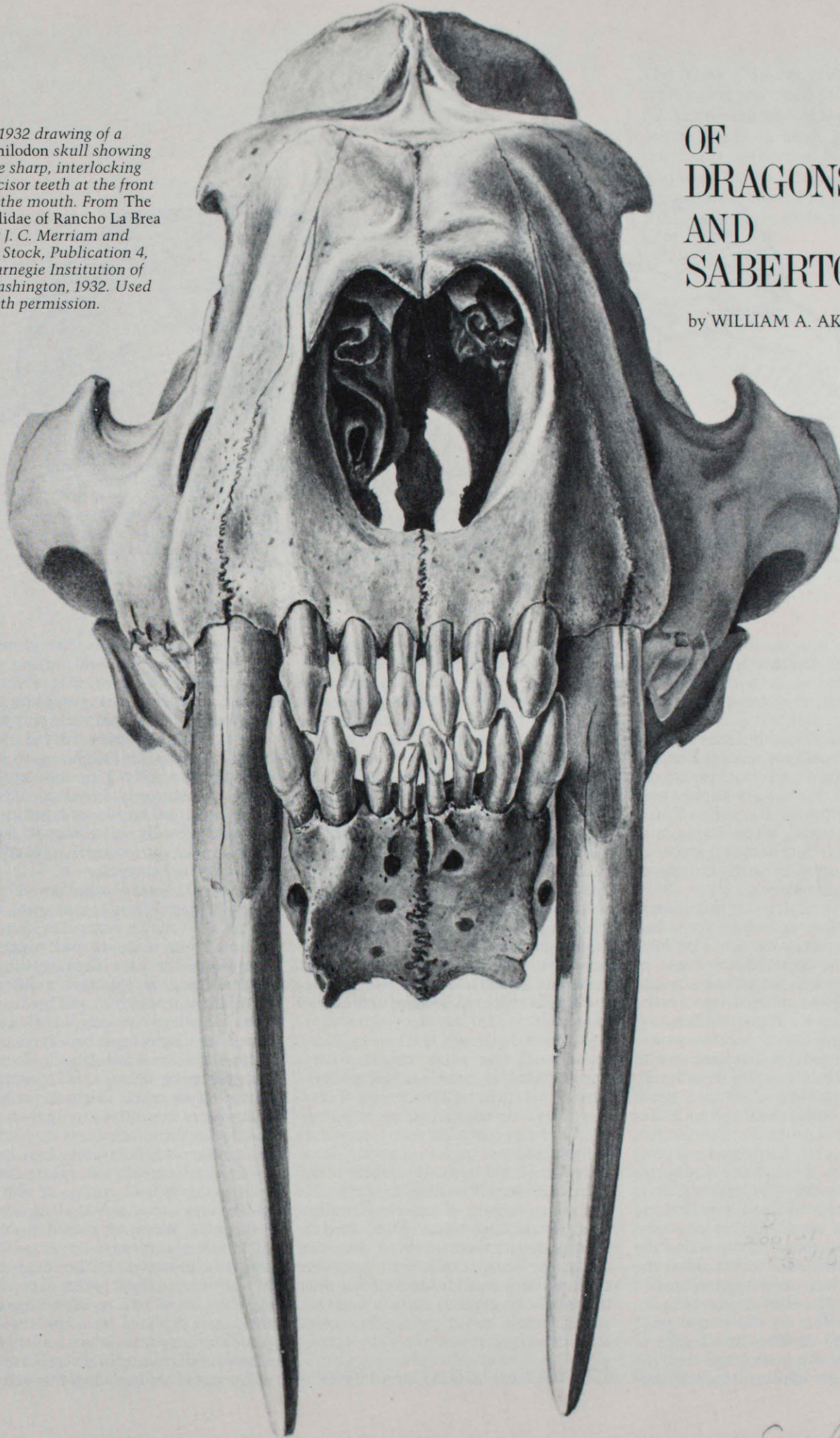
Dr. Keller is a Research Associate of the Mineralogy Section and was consultant in charge of the development of the new Gemstones and Their Origins exhibit at the museum. He has traveled extensively studying gem deposits around the world.

Dr. Kampf is Curator and Head of the Mineralogy Section and collaborated with Dr. Keller on the development of the new gemstone exhibit. His research interests include the identification and description of new minerals and the study of pegmatites.

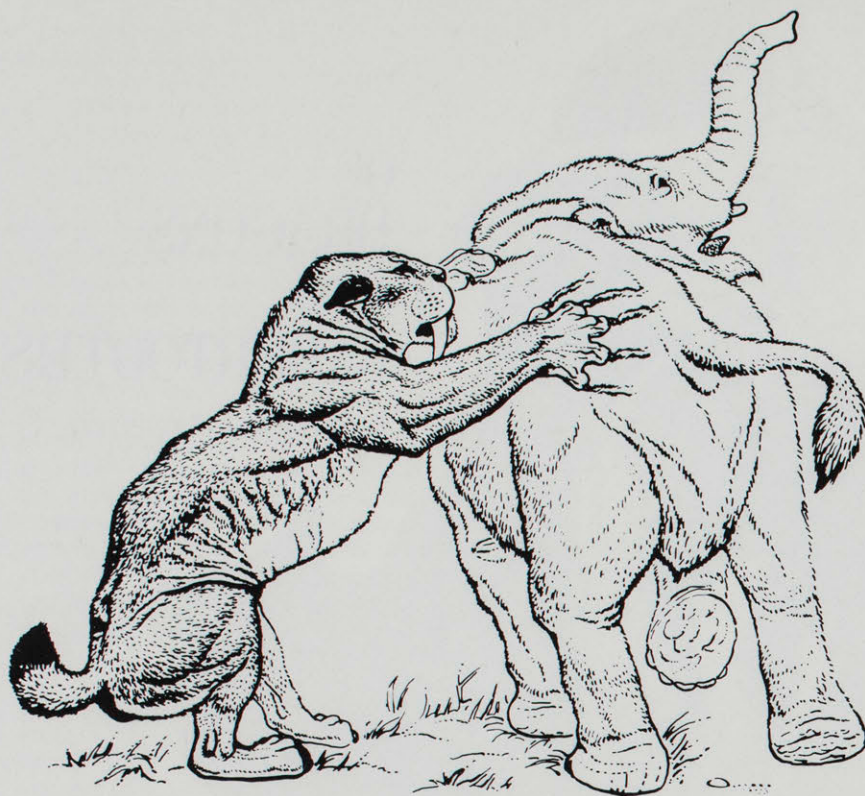
A 1932 drawing of a Smilodon skull showing the sharp, interlocking incisor teeth at the front of the mouth. From *The Felidae of Rancho La Brea* by J. C. Merriam and C. Stock, Publication 4, Carnegie Institution of Washington, 1932. Used with permission.

OF DRAGONS AND SABERTOOTHES

by WILLIAM A. AKERSTEN



Sabre tooth



The initial stages of a sabertooth attack. Left, Smilodon using its powerful forelimbs to pull down a young mammoth. Page 15, leaning over to start a shear-bite to the mammoth's exposed abdomen. Drawings by Mark Hallett.

Let your imagination carry you to the Los Angeles of some thirty thousand years ago, well before the days of concrete, automobiles, and museums. The wildlife is quite different: camels, ground sloths, mammoths, and sabertoothed cats have not yet been replaced by punk rockers, winos, bikers, and bag ladies. Yet the air already contains a hint of things to come as hydrocarbons evaporating from seepages of natural asphalt at the future site of Rancho La Brea react with sunlight to form a faint haze of smog.

A small herd of female mammoths with their infants peacefully feeds just after daybreak, unaware that a pride of *Smilodon*, the sabertoothed cat of Rancho La Brea, is scattered out and approaching from downwind. As the mammoths move about, individual sabertooths maneuver to get close to several of the older infants that have strayed from the adults during play. Finally, the frisky group gets too close to a small thicket where one of the sabertooths lies in ambush. It covers the distance in a few bounds and uses its sharp claws and powerful forelimbs to pull the youngster down on its side. The mammoth is stunned by the violent attack long enough for the cat to quickly bite open the unprotected abdomen. Several of the adult mammoths rush to the aid of the injured one while others gather around the remaining juveniles to protect them. The attacker flees as the entire pride retreats a small distance and begins to roar, secure in the knowledge that the enraged female mammoths will not

leave their young to wreak vengeance.

The young mammoth lies in shock for a while, bleeding profusely. Later, at its mother's insistence, it tries to rise, but fails. The herd keeps a careful watch during the mother's efforts to aid her dying youngster. But the ceaseless din of roaring sabertooths underscores the constant danger to the remaining young, and the herd ultimately has to abandon the almost-dead infant and its mother. The mother remains for a few hours, making short charges toward one or another of the sabertooths as they cautiously begin to edge close (even an entire pride of sabertooths is not about to attack a fully mature mammoth). By dusk she too recognizes the futility of the situation and abandons her now dead baby, following the rest of the herd to safer and quieter pastures.

With her departure, the hunters claim their meal. An aged female with a crippled hind leg, unable to help with the hunt, joins them in a brief orgy of feeding. They tear the carcass apart by tugging and ripping with their protruding incisors and making an occasional, carefully placed bite with the sabers to lay open a new area. The long, rather doglike lips characteristic of sabertooths allow them to take large pieces of flesh into the side of their mouths behind the saber where the sharp cheek teeth can slice the food into swallowable pieces. Soon the pride is gorged; only bones and scraps remain to satisfy the assembled scavengers.

How realistic is this gory scenario? Is

there good evidence that groups of female mammoths with nursing young formed separate groups; that sabertooths roared, lived in prides, preyed on young mammoths, and killed their prey by biting open the abdomen instead of stabbing the neck? Or is this pure speculation, sometimes called *paleopoetry*? Certainly this scenario differs considerably from previous ones—and future ones will undoubtedly differ from it! For me, this is one of the fascinations of working to reconstruct the past.

Relatively little can be proven beyond a doubt. Instead, paleontologists try to gather all available types of evidence and reason from them to put together a glimpse of the past. Because the same evidence may be interpreted differently by different researchers and because new work constantly reveals additional evidence, total agreement between students of fossils is rather rare. This leads to a lot of interesting debates and discussions whenever we meet. The basic problem is that we can never have more than a tiny fraction of the information we need. You can tape-record the roar of a lion, but not that of a sabertooth; naturalists can conduct in-depth field studies of chimpanzee behavior, but not that of australopithecines. We must reason from very incomplete evidence—from whatever might be preserved in the fossil record. My favorite analogy is that reconstructing the past is like trying to figure out the scene depicted by a one-thousand-piece picture puzzle when you only have a handful of the pieces. Even if a number of key pieces are included, you will never

The frisky group of young mammoths gets too close to a small thicket where one of the saber-tooths lies in ambush. It covers the distance in a few bounds and uses its sharp claws and powerful forelimbs to pull a youngster down on its side.



be absolutely certain of the whole picture. And anyone else you might show the pieces to will almost certainly come up with a different interpretation. With this in mind, let us look at some of the reasoning behind the scenario.

We do not know what type of herd behavior the extinct mammoth may have had, so we make an analogy with a living species. Dr. Russell Graham of the Illinois State Museum has suggested that female mammoths with nursing young may have formed separate groups because that is what the mammoth's closest living relative, the Asiatic elephant, does.

We also have no evidence whatsoever about what animals *Smilodon* preyed upon. Here the analogy must be drawn with a slightly different extinct saber-tooth called *Homotherium* that has been found in a Texas cave with the remains of scores of baby mastodons and mammoths. Remains of other predators are scarce in the cave, and the skeletons of several very young *Homotherium* kittens have been found. Dr. Graham and others have interpreted these finds as indications that the cave was a *Homotherium* lair and that the young proboscideans were killed and dragged in by the sabertooths.

George Miller, formerly in charge of the Rancho La Brea Project (see "The Resurrection of Pit 91" by Mary Lorraine Romig, *TERRA*, September/October 1984) and now at the Imperial Valley College Museum, showed that sabertooths must have had a long, doglike lip line because they opened their mouths so widely. Most reconstructions have

shown relatively short lips, like modern cats. Miller pointed out that such short lips would have been stretched out of shape when *Smilodon* fully opened its mouth to use its canine teeth.

What about *Smilodon* roaring? Again, we draw conclusions based on anatomical structure. Antonia Tejada-Flores, Research Associate at the Page Museum, has identified and studied the previously unknown throat bones, called *hyoids*, of *Smilodon* in the Rancho La Brea collections. The hyoids of modern cats fall into two structural groups. One group has a pair of relatively solid interconnections and is found in cats that do not roar. The other group has a pair of very elastic interconnections that allow their possessors to roar. The *Smilodon* hyoids closely resemble those of roaring cats, so it is reasonable to think that they were capable of roaring. But we cannot be certain how they might have actually used this capability. Use of the roar to upset and drive away other animals was suggested to me by Jonathan Kingdon when he visited the museum in connection with his exhibit of incomparable animal portraits (see "Eye and Pencil, Stripe and Horn" by Jonathan Kingdon, *TERRA*, Spring 1983).

Perhaps the most radical interpretations in the scenario are in depicting the prides of *Smilodon* engaged in cooperative hunting and making a kill by biting at the abdomen of their prey. These are my contributions to the scenario, interpretations made in a recently completed study (see the museum publication *CONTRIBUTIONS IN SCIENCE*,

Number 356).

Evidence for group social behavior rests upon two types of information: the great abundance of *Smilodon* at Rancho La Brea and the large proportion of crippled individuals. *Smilodon* is the second most abundant large carnivore recovered from La Brea. The other two very common carnivores, dire wolves and coyotes, were almost certainly social animals that hunted cooperatively to some extent. On the other hand, animals that primarily hunt alone are much more rarely found in the tar pits: mountain lions, bears, jaguars, and so on. The great numbers of the sabertooth place it in with the social forms.

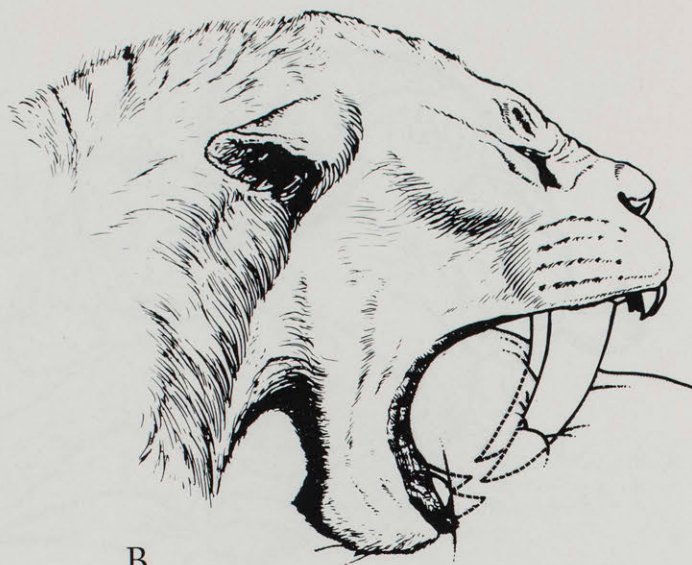
Many *Smilodon* specimens show evidence of crippling disease. They simply could not have hunted for themselves, yet they survived for a long time after being injured. It has been argued that these incapacitated animals survived by scavenging. However, since most other large predators scavenge whenever possible, it seems unlikely that so many crippled sabertooths could have competed successfully for carrion. Several social predators, such as African lions, do allow disabled members of their group to feed at kills. I interpret the numbers of injured *Smilodon* to indicate similar behavior and that they did possess some overall degree of social cooperation. There is no evidence regarding the extent of cooperation during the hunt, and this part of the scenario is pure paleopoetry.

The interpretation of *Smilodon* and other sabertooths as having bitten their prey rather than stabbing or slashing at it

Reconstruction of *Smilodon's* shear-bite. A. Jaws starting to close, catching a fold of flesh. B. Jaws closed to the point that the upper and lower canines have penetrated the fleshfold. At this stage the jaw-closing muscles can no longer develop enough force to finish the bite, and, in conjunction with pressing the chin flanges against the prey, serve



A



B

is a radical departure from current dogma. I had completely accepted sabertooths as stabbing or slashing forms until I began to take a closer look. If one spends much time with Rancho La Brea material, it is almost impossible to avoid being fascinated by these beasts. My interest began shortly after I came to the museum as Coordinator of the Rancho La Brea Project in 1972. A number of years were to pass before I could really get to work on *Smilodon* because other duties consumed most of my time and, until completion of the new storage facilities at the George C. Page Museum and curation of the specimens, the Rancho La Brea sabertooth fossils were all but inaccessible.

At the time I began, there was a mild controversy as to whether sabertooths killed by a stab or with a slashing technique. I thought that it might be possible to settle the question with our huge and well-preserved collections. I immediately ran into a theoretical problem regarding the evolution of sabertooths. Sabertooth-type animals evolved independently from at least four groups of mammals: from among true cats, from extinct catlike animals called *nimravids* (the skeleton of *Dinictis* and *Hoplophoneus* on exhibit in the Hildegard Howard Cenozoic Hall of our museum are examples of *nimravids*), from another group of extinct, primitive carnivores called *creodonts*, and from South American carnivorous marsupials. All share a number of features that define them as sabertooths. Among these are enlarged upper canine teeth ("sabers"), evidence

for very powerful head-depressing muscles, a flange on the bottom of the front part of the lower jaw, and several features that seem to indicate that these animals had a relatively weak mechanism for closing the lower jaw. Yet, as far as we know, all evolved from typical carnivore types that bite with normal-sized canines, have much weaker head-depressing muscles, and very strong jaw-closing muscles.

I had thought that one way to approach the problem was to try to determine whether stabbing or slashing was theoretically more likely to evolve from biting ancestors. To make a very long story very short, each seemed totally impossible! While wrestling with the question, I compared skulls of biting carnivores with the only *Smilodon* specimen from La Brea, which, out of more than six hundred *Smilodon* crania, had complete sabers and a lower jaw known to belong to it. While this did not help me to envision the evolution of stabbing or slashing from biting, it did show me what turned out to be an important key to the whole problem.

Modern carnivores can force their canines into another animal because the lower and upper canine teeth act against one another. This canine opposition occurs because the tips of the teeth pass each other very closely during closure of the mouth, the tip of the lower passing slightly inside of and slightly in front of the upper. If the carnivores tried to make a puncture without using canine opposition, they would fail. In the one key *Smilodon* skull, the canines do oppose

one another in exactly the same way. Old, ingrained ideas die hard. I did not immediately leap to the conclusion that sabertooths were biting animals, as the canine opposition would suggest, but tried to imagine how biting could be combined with an initial stab or slash.

By this time it became quite obvious that I needed to take a hard look at all those features of *Smilodon* that might shed some light on the question. At first glance the saber does appear to be like its namesake: a sharp, thin blade. But a more careful look shows that it is a far cry from a modern steel knife. *Smilodon's* saber is actually rather thick and has a tip that is duller than a butter knife. How could a pair of such weapons be driven into the hide and flesh of a large prey animal when it is not an easy task to do the same thing with one well-sharpened steel knife? I could not imagine how this could be accomplished even by the animal drawing its head far back and using the powerful head-depressing muscles to drive the sabers downward into the prey as suggested by prevailing ideas. Besides, with the head drawn back, the sabertooth would be staring off into space, unable to see where it was striking.

Was there good evidence for powerful head-depressing muscles? I decided that the marks muscles left on the bones of the head and neck showed that *Smilodon* had even more powerful head-depressing muscles than previous workers had believed, especially those muscles that would rotate the head

SPECIAL EVENTS



Craft Fair and Hoedown

Sunday, June 2, 1985
10 a.m. to 4:30 p.m.

Dust off your Stetsons and bonnets, polish up your boots, and get ready to kick up your heels at a one-day, old-fashioned hoedown. On June 2, the Tenth Annual Craft Fair will re-create the pioneer spirit through demonstrations of traditional American crafts such as sheepshearing, horseshoeing, saddlemaking, quilting, spinning, silhouette cutting, wood carving, and folk art. Square dancers and cloggers will step lively to bluegrass music while fairgoers chow down on chuck wagon fare. The fair will be taking place on the south lawn and throughout the museum; there will be special events for children of all ages—and, after participating in all the

activities—museum visitors can end the day with a horse-drawn hayride through Exposition Park.

Weekend Gem Seminar

May 3–5, 1985

To celebrate the opening of the new Alex Deutsch Gallery, Gemstones and Their Origins, the Natural History Museum of Los Angeles County, in cooperation with the Gemological Institute of America, will be offering a comprehensive introductory course in gemology. Whether you are a professional jeweler, amateur mineralogist, or gem collector, this course will be of educational and practical value. Conducted by two GIA instructors, one an expert in diamonds and the other a specialist in colored stones, the course will consist of lec-

tures, discussions, and slide presentations. In addition, there will be a special preview of the new gem gallery and a behind-the-scenes presentation by museum staff members.

Participants will meet on Friday evening for an orientation meeting and get-acquainted social at the museum. All-day sessions on Saturday and Sunday May 4 and 5 begin at 9 a.m. and end at 5 p.m. The course's cost is \$175 per person, which includes lunch and parking on Saturday and Sunday. For more information, please call 213/744-3341.

MEMBERS' TRAVEL PROGRAM

ROMANTIC CITIES OF EASTERN EUROPE, May 2–13, 1985 Vienna, Budapest, and Prague are three contemporary European capitals that continue to evoke an aura of Old World elegance and romance. We'll savor the coffeehouses and palaces of Vienna, see the bridges that weave Buda and Pest into a wonderful fabric of folk art, and visit Prague—the city of a hundred spires. The Vienna Woods, Prague's castle and gothic cathedral, and Budapest's gypsy music and Liszt concertos await you. There will be time to shop in all three cities as well as in Helsinki. \$1799, including airfare.

TROPICAL ECOLOGY: THE AMAZON, June 25–July 19, 1985 Our amazing Amazon adventure takes place in the extreme northeastern portion of Peru. Early morning bird walks, night hikes, overland explorations, and boat tours of the Amazon will be part of our observation and study of several superb, undisturbed Amazonian habitats. Participants will travel the river via float plane, canoes

(large dugout canoes with sides and roof), and small dugouts. Dr. Charles Hogue, the museum's curator of Entomology, will be accompanying us on this trip, which is offered in cooperation with UCLA Extension and the American Horticultural Society. Around \$3275, all inclusive.

THE MAGNIFICENT NORTHEAST PASSAGE, July 6–12, 1985 Cruise Canada's Saint Lawrence Seaway and along the coast of Nova Scotia and New England. The air is crisp and clean along these shores of unspoiled beauty and ports rich in the maritime history of North America. From New York City the cruise will pass through Newport, Rhode Island; Fall River and New Bedford, Massachusetts; Cape Cod Canal; Sydney and Halifax, Nova Scotia; Bonaventure Island and Percé Rock; the Saguenay River, Quebec City, and Montreal. From \$1475, including airfare.

KENYAN SAFARI, August 19–September 1, 1985 Explore some of the most breathtaking scenery in the world, from snowcapped mountains to lush river valleys, endless savanna plains to jungle forests. Photograph some of the most spectacular wildlife in the world. Travel with Kimball Garrett, Ornithology collections manager, to Nairobi, Mount Kenya, Lake Nakuru, and Masai Mara. Optional extension trips are available August 16–20 to London and August 31 to September 5 to Mombasa. \$2940, including airfare.

CHINA & YANGTZE RIVER ADVENTURE, September 3–19, 1985 Come join us for a truly exotic adventure through China! Our cruise down the Yangtze, the world's third-largest river, will take us where few Western travelers

have sailed—through the three Yangtze Gorges with a wild beauty so spectacular that it is impossible to exaggerate their splendor. We will visit Beijing's Forbidden City, the gardens and pavilions of the Summer Palace, and the Ming tombs. Visit an agricultural commune, silk factory, oriental rug factory, museums, the Beijing Zoo, and the World War II capital Chongqing. We'll go shopping in Hong Kong, feast on Peking duck, and walk along the Great Wall. This trip is during the cooler fall weather when traveling in China is most comfortable. From \$3899, including airfare.

EGYPT & THE NILE, October 10–25, 1985 Travel back in time nearly five thousand years with expert Egyptologist and accomplished archaeologist Dr. Nabil Swelim. We will see the remarkable step pyramid of Pharaoh Zoser, the ageless stare of the mysterious Sphinx, and the temple remains of Karnak and Luxor. Experience the exotic Khan el-Khalili Bazaar, bustling Cairo, and the charms of Aswan. The trip includes an eight-day cruise down the Nile. From \$3491, including airfare.

INDIA & NEPAL: TEMPLES & TIGERS, November 8–24, 1985 Starting in Nepal, the fabled jewel of the Himalayas, visit Katmandu, set against the backdrop of snow glistening on the highest mountain in the world. Elephants will transport us on a safari through Chitwan National Park, where we will look for tigers and leopards from special blinds and stay in the famous Tiger Tops Jungle Lodge. In India we will float down the Ganges to see the Hindu faithful worshipping at the Ghats, view the Taj Mahal by moonlight, see the beautiful Amber Palace, and exotic temples. We will view rare

wildlife at Bandavgarh National Park, including the one-horned Indian Rhino, and the Bird Sanctuary at Bharatpur. The trip will be escorted by an Indian expert on the cultural history and ecological heritage of the varied and exotic subcontinent in addition to other expert guides. From \$2447, plus airfare.

GREECE, November 4–17, 1985 Our trip to Greece will focus on the natural history of this beautiful and ancient country. We will see the sights of ancient Athens, the 2300-year-old Parthenon, royal palace, Hadrian's Arch, and Temple of Olympian Zeus. Mystas, a dead Byzantine city, is the equivalent of Pompeii in its completeness—a vast museum of architecture, sculpture, and decorative art. By boat we'll tour the Diros Caves, some of the world's most beautiful lake caves. At Olympia we will see the stadium where the first Olympic Games were held in 776 B.C. Drives through the countryside and short walks through mountain forests will allow us to see parts of Greece most tourists miss. From \$1759, including airfare.

COSTA RICA, November 1985 and ANTARCTICA, January 1986 See the next issue of TERRA for more information or call the Membership Office at 213/744-3426.

The following local trips are offered through California Natural History Tours. Most trips are accompanied by a natural history expert from the museum. Call 213/744-3426 for more information.

GOLD DUST COUNTRY, May 17–20, 1985 Explore traces of California's rich and rugged past—the 49ers, the ranchos, and the land grants. \$565 per person.

THE INDIANS AND THEIR ROCK ART, May 25–27, 1985 A three-day excursion to

explore Indian sites in the Tehachapi and southern Mojave areas. \$225 per person. Tents, transportation, and meals provided.

ELEGANT WINE PILGRIMAGE, May 31–June 4, 1985 A delightful small tour of many California wine areas, interweaving history and nature. You will stay in enchanting historic inns and hotels. \$795 per person.

COLORED GEMSTONES, June 8–10, 1985 Tourmaline, topaz, garnet, and smokey quartz are some of the gemstones found in northern San Diego County. We will visit several gem mines and also meet a collector and view his collection of gemstones. \$455, including meals, transportation, and lodging.

GHOST TOURS WITH MYSTERY GUEST, June 15–16, 1985 Join us in a ghost hunt in Los Angeles and Orange counties. A famous mystery guest will join us—bring your ghost stories! \$59, including transportation, dinner, and breakfast.

ANTIQUÉ FARM MISSION & RANCHO TOUR, June 22, 1985 This tour includes the largest mission and one of the oldest Mexican ranchos in California. \$45 including transportation and lunch.

SHIFTING SANDS, June 23, 1985 From the granites of the mountains to the tiny grains of sand below the Pacific, we will learn about the ever-changing sands of our beaches. \$45

EARTH AND SKY, August 10–11, 1985 A geologist will lead us through earthquake country and the Tehachapis, followed by a program under the stars as meteors streak across the sky. \$175, includes food for two full days, tent, and transportation.

SANTA CRUZ ISLAND, RANCH HOUSE, August 16–19, 1985 Stay with us in a rustic ranch house surrounded

with nature and history, with our own private mile-long beach just a short distance away. Archaeological sites, forests, and beaches will be visited. \$495, including all meals, lodging, boat & jeep transportation.

Travel Notes

LENINGRAD, February 1985. To some, winter in Russia evokes *Dr. Zhivago* images of horse-drawn sleighs carrying lovers huddled under snow-flecked furs. To the less romantic, it translates into bitter cold, charcoal-gray skies, and icy winds that bite through endless layers of clothing.

Last February, seventeen romantic and hardy members risked the chances of sub-zero temperatures for a truly unusual experience on a museum-sponsored trip to Leningrad.

Formerly Saint Petersburg, and once the capital of Czarist Russia, Leningrad lies on the shore of the Baltic Sea in northwest Russia. Considered to be one of the most beautiful cities in the world, it is also an important cultural and educational center. Leningrad is dotted with palaces, museums, monuments, and churches, unique in their harmonious architecture. Best of all, Leningrad was designed for winter. The stately buildings rise above snow-covered parks and squares in shades of colorful pastels.

The trip's focal point was the world-renowned Hermitage Museum. Built as a winter palace and court museum by Catherine the Great, its many rooms house collections of old and modern European paintings, Western decorative arts, and antiquities from Greece, Rome, and the Near and Far East.

We began our journey with



Jane Herwegh

a two-day visit to cheerful, colorful Helsinki, Finland. From there, we boarded an Aeroflot plane for the short hop to Russia. We were taken to a large hotel on Leningrad's outskirts that housed a variety of tourists from all over Europe. Americans are often accommodated here because of the excellent plumbing, so we didn't need the sink stoppers we'd been warned to bring along.

The hotel feeds hundreds of guests at the same time, each tour group sitting together. The groups were served the drink the Russians thought most appropriate—they had difficulty understanding why we didn't want to drink Pepsi with every meal! In retrospect, I wonder if the British were served tea with every meal, and, better still, the Germans beer?

After a tour of the city, we had our first taste of the Hermitage. We entered the inner sanctum of the treasure rooms to view the collection

of gold objects, which range from ancient Greek jewelry to the Romanov's crown jewels. The collections are not housed in modern display cases, but in eighteenth- and nineteenth-century armoires, museum pieces themselves.

The next day we visited the various galleries of the museum proper. The Hermitage has an unmatched collection of European paintings; the Rembrandt gallery, for instance, contains seventeen Rembrandts and several other paintings from his school. A whole room chronicles the transition from Picasso's blue period to his innovative cubist style. Room after room is filled with decorative Russian furniture of the empire, regency, and art nouveau periods. These furnishings were interesting in that their design is the Russian interpretation of these styles, which emphasizes their love of bright colors. A personal highlight was meeting a Russian counterpart—

This newlywed couple is heading for shelter from the -10 degree cold after posing in front of the Hermitage, part of the traditional circuit of public monuments newly-married couples make after their simple civil wedding service. Right: Intourist (the Soviet tourist organization) awards this pin, which says "Russia Winter," to travelers that brave touring in the winter chill. The pin below shows an Olympic Stadium.



NEWSLETTER

an exhibits designer—and comparing mutual trials and tribulations.

Our other encounters with the Russian people were rare and brief. We discovered pin trading was not strictly an Olympic event. Pins cross the barriers of culture and language. Add ballpoint pens and chewing gum, and those barriers come tumbling down.

Our evenings were spent enjoying other aspects of Russian culture. We spent one night at the opera and another at the ballet; we also visited the famous Moscow Circus on Ice. We were reminded of the international language of laughter as we joined with the Russians in watching the giant bears cavorting on skates. No translator required.

Jane Herwegh
Senior Museum Technician



MUSEUM DEVELOPMENT Automotive Collection Council Formed

In late 1984, a group of local businessmen and car enthusiasts formed the Automotive Collection Council, the first of several councils to be organized within the museum. The major purpose of the support council program



The museum's 1963 Chrysler Turbine.

NATURAL HISTORY MUSEUM AUTOMOBILE COLLECTION, MARCH 1985

Year	Make	Model	Cyl.	HP	Body type
1907	Aerocar	C	4	20	Runabout
*1953	Allard	K	V-8	235	Roadster
*1911	American (Underslung)	Traveler	4	50	Touring
1897	Anthony (Electric)				Runabout (replica)
*1907	Auburn	D	2	24	Touring
1904	Autocar	VIII	2	12	Touring
1910	Baker (Electric)	V			Coupe
1906	Black				Runabout
1957	BMW	507	V-8	150	Coupe (Raymond Loewy)

1900	Breer (Steam)			2	Stanhope	
1920	Burnett-Brunell				Roadster	
1911	Cadillac	30	4	30	Chassis	
*1951	Cadillac, Jack Oakie		V-8		Fleetwood	
1910	Chalmers-Detroit		30	4	30	Touring
*1963	Chrysler	Turbine			130	Coupe
*1948	DIVCO			4		Delivery (Helms truck)
1917	Dodge			4	30	Touring
*1932	Duesenberg	J		8	265	Roadster (Murphy)
1909	Durocar	L		2	26	Touring
*1909	Ford, 2-lever	T		4	20	Touring
1911	Ford	T		4	20	Touring
1913	Ford	T		4	20	Touring
1922	Ford	T		4	20	Coupe
1929	Ford	A		4	40	Coupe
*1966	Ford	Mustang		6		Coupe
1903	Franklin			4	10	Roadster
1904	Franklin	A		4	10	Roadster
1908	Franklin	G		4	18	Roadster
1910	Franklin	G		4	18	Roadster
1912	Franklin	D		6	38	Roadster
1912	Gorham-Seagrave			4	96	Fire engine
*1954	Jaguar	XK-120 M		6	160	Coupe
*1942	Jeep (Ford)	GPW		4	45	Recon. truck
1917	Jeffrey			4	38	Touring
1903	Knox	Murray		1	8	Delivery
*1957	Lincoln Continental	Mark II	V-8			Coupe
1912	Little			4	20	Roadster
1900	Locomobile (Steam)	2		2	5	Stanhope
1907	Locomobile	E		4	20	Touring
*1927	McFarlan	842		8	35	Roadster
1948	MG Midget	TC		4	54	Roadster
*1948	MG Midget, modified	TC		4	135	Roadster
*1913	Moreland	E		4	27	Truck
*1902	Oldsmobile	Curved Dash		1	4	Runabout
†1908	Pierce	Great Arrow		6	60	Touring
*1911	Pope-Hartford	Y		6	50	Roadster
1910	Stanley (Steam)	70		2	20	Touring
†1907	Studebaker	G		4	35	Touring
1915	Studebaker	E-C-V		6	30	Touring
*1915	Stutz, Earl Cooper			4	130	Racing car
*1902	Tourist			2	12	Touring
1903	Tourist			2	12	Roadster
1901	Tuckermobile					Roadster
1931	Twin-Coach			4	35	Delivery (Helms)
†1909	Welch	4-0		4	50	Touring
1909	White (Steam)	0		2	10	Touring
1917	White	6-60		6	60	
*1900	Winton			1	6	Runabout
1917	Woods (Gas-Electric)			4		Coupe

*Restored or original cars suitable for display.

†Heritage car to be preserved in original condition.

is to provide ways for individuals interested in a particular aspect of the museum to further their knowledge of the subject in association with fellow enthusiasts and under the guidance of a curator. Councils also engage in activities in support of curatorial collection and research endeavors. In addition to the Automotive Council, Bird and Gem Councils are being formed. If you would like more information, please call Mike Bell at 213/744-3438.

One of the goals of the newly founded Automotive Collection Council is to make southern California automotive enthusiasts aware of the museum's engine-powered treasure trove, which currently contains fifty-nine cars and trucks.

The collection was started in 1929 with the donation of a then fairly new 1909 Welch Touring Car. Today it includes an 1897 Anthony Electric as well as a 1963 Chrysler Turbine experimental model. In the main, American makes predominate, with an emphasis on cars and trucks built in Los Angeles.

Donations have accounted for most of the acquisitions; the largest single collection, the Wohlbruck collection, was donated in 1937. T. C. Wohlbruck was a San Jose photographer who amassed more than one hundred cars and a large store of automotive memorabilia. At Wohlbruck's death in 1935, his widow offered the cars to the museum for \$100,000. This was more than the board could pay, so the offer was reluctantly rejected. Most of the collection, about ninety autos, went to the Ford Museum. However, because of the close friendship between the Wohlbrucks and museum curator Ransom Matthews, Mrs. Wohlbruck gave eleven

of the best cars to the museum. Her gift included a 1908 Pierce Great Arrow, a 1907 Studebaker, and a 1910 Stanley Steamer.

In 1962 the collection numbered thirty-two cars. Since then, twenty-seven automobiles have been added by purchase and donation. Vehicles from the collection are exhibited on a rotating basis in the Automotive Gallery on the museum's ground floor. The remaining vehicles are stored in museum warehouses, where restoration also takes place.

The specific goals of the new Automotive Collection Council are:

- To deepen the knowledge of council members through a series of activities and programs jointly planned and sponsored by the council and the museum.
- To assist in the restoration and maintenance of vehicles through contributions from council members;
- To acquire vehicles and other automotive materials for the collection, and to recognize and honor enthusiasts and firms responsible for these acquisitions;
- To acquire a separate building to house and display the entire collection.

The council extends an invitation to all automotive enthusiasts to join them in the pursuit of these goals. Yearly membership dues are \$100, and inquiries should be directed to Mike Bell at 213/744-3438.

The Fellows of the Natural History Museum

Collections are the heart of every museum. Supporting the Natural History Museum is a very special human collection that may be considered the heart of its annual giving



Mrs. Arthur Lee Crowe, Jr., and James R. Young, co-Chairmen of the Board of Trustees Fellows Committee.

Dick Meier

program. These individuals, the Fellows of the Natural History Museum, provide unrestricted support for museum operations by making a yearly contribution of at least \$1,000.

The Fellows program, modeled on successful ventures at similar institutions, was initiated in 1982. There are now 90 members. The expansion of the group is due in large part to enthusiastic promotion by its members to their friends and associates. To further the growth of the Fellows program, an Alliance Board committee has been formed; the goal is to raise the number of Fellows to 125

by July 1985.

Fellows receive special recognition in several ways. All Fellows receive invitations to exhibit openings as guests of Dr. Craig Black, the museum's director. This year Fellows will also have added opportunities to meet the curatorial staff and explore special interests, as well as participate in Fellows-only events. Names of all Fellows are included on the handsome plaque at the North Entrance, and every Fellow is accorded parking privileges at Coliseum events. These benefits are, of course, in addition to all the regular benefits of museum mem-

bership. Further information about the Fellows may be obtained by calling Mike Bell at 213/744-3438.

Corporate Support on the Rise

The number of Business Associates, corporations and corporate foundations that provide annual financial support to fund the Natural History Museum's research and educational programs, has grown by almost 40 percent since July 1984. The museum is making a special effort to inform the corporate community of what a tremendous cultural and educational asset it is for the people of southern California. The response has been extremely heartening, according to Board of Trustees Business Associates Committee co-Chairmen Dan McGurk and Steve Onderdonk. Sixty-five member corporations now contribute from \$1,000 to \$10,000 each year. In addition to receiving full membership privileges, representatives of the companies are given special invitations to museum exhibit previews and member recognition events with internationally renowned speakers. Each Business Associate is recognized on a special plaque at the museum's north entrance.

In a series of luncheons hosted by Dr. Craig Black, the museum's director, for Business Associates and other corporate friends, Dr. John Harris, Chief Curator of Earth Sciences, Dr. Ralph Schreiber, Ornithology Curator, and Mrs. Joan Grasty, Acting Head of Education, briefed the corporate community on the museum's current programs and its plans for the future. Dr. Harris, who was formerly with the National Museums of Kenya, told about partici-

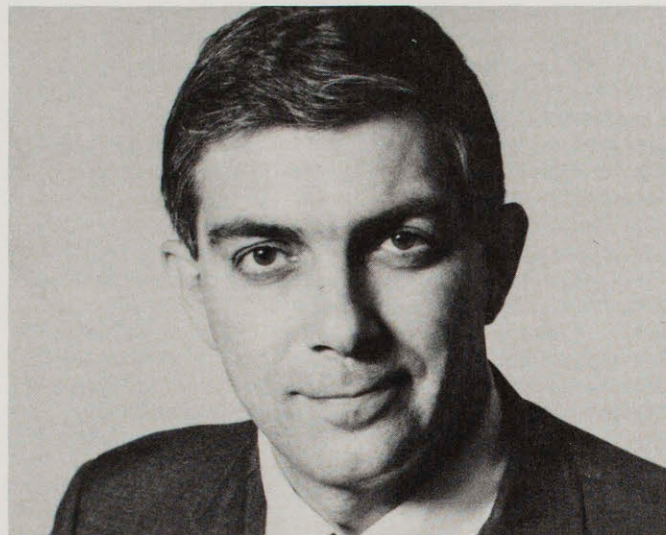
pating in the discovery of the most complete skeleton of *Homo erectus* yet found in Kenya last summer. Dr. Schreiber described his research on the birds of Christmas Island and especially the effects of El Niño. Mrs. Grasty described the museum's School Tour and Lending Service programs and let the corporate visitors know about the Moveable Museum and its recent expansion to include the handicapped and elderly in southern California.

Companies represented at the luncheons included American Medical International, Atlantic Richfield, Carnation, Community Bank, Crocker Bank, Disney, Ernst & Whinney, First Interstate Bank, Garrett, General Telephone, Honda, Hughes Aircraft, IBM, Lloyds Bank, McDonnell-Douglas, National Medical Enterprises, Nissan, Santa Fe International, Security Pacific Bank, Texaco, Transamerica Occidental Life, Union Bank, Unocal, and U.S. Borax & Chemical.

For more information about the Business Associates, please call Don Gross at the Foundation Office 213/744-3307.

The Natural History Museum Foundation Board of Trustees

As you browse through this issue of TERRA, you will find a new listing on the inside back cover of the Museum Foundation's Board of Trustees. The Trustees make up the governing body of the Natural History Museum Foundation, which was established twenty years ago as a nonprofit, charitable organization to facilitate private sector support as a supplement to Los Angeles County appropriations used to run the museum. Currently, funds



Robert S. Attiyeh, the Natural History Museum Foundation Board of Trustees President.

generated through Foundation efforts account for 15 percent of the Natural History Museum's operating budget. County appropriations cover 60 percent of this amount, and a combination of federal research grants and income derived from contracted services performed for industry plus earnings from a small endowment provide the remaining 25 percent.

The forty-five men and women on the Foundation Board, sixteen of whom are Governors chosen by the County Board of Supervisors, voluntarily give of their time, energy, and resources in formulating program enrichment policies and providing the funding to carry them out. They receive no compensation other than the satisfaction many of you share with them of contributing to the betterment of our museum and community.

Working in tandem with our director, Dr. Craig Black, and his staff, the Foundation Trustees contribute to the continuing progress and vitality of the museum. "For nearly seventy-five years our museum has been a valued

part of the southern California community," says current Foundation Board President Robert S. Attiyeh. "Despite its many past accomplishments, however, the museum must work hard to keep pace with the expanding cultural and educational interests and needs of our community."

Specifically, Museum Foundation Trustees have several key, ongoing duties. They exercise responsibility through Dr. Black for the general policy and administration of the museum. They monitor finances and approve the annual budget for submission by the Governors to the county. The Trustees and Governors work together to define museum goals and to ensure consistent pursuit of these goals, including the development of new facilities. In addition, each Trustee represents the museum to the public and to potential sources of financial support. A Foundation Trustee also becomes a representative to the community at large to help bring about better programs and to develop a wider circle of museum friends and supporters.

To accomplish these goals,

each Trustee becomes a knowledgeable spokesperson for the museum by familiarizing himself or herself with its many facets and activities. This process begins with an orientation program. Over time the Trustee develops broader knowledge of the museum through board meetings, curatorial briefings, service on one or more standing committees, and participation in such museum activities as fund-raising programs, the Dinosaur Ball, museum councils, exhibit openings, and special receptions. With involvement in these and other programs, Trustees are better able to review, assess, and contribute to museum progress.

Trustees serve terms of varying lengths, while Governors serve at the pleasure of the appointing county supervisor. Board meetings are held four times a year at the museum, with an executive committee providing continuity and leadership between meetings.

Grant for Moveable Museum Received

The Natural History Museum has recently been awarded a grant from National Medical Enterprises, Inc., the second largest health services company in the United States, to expand the scope of the Moveable Museum.

Created in 1982 to bring the museum to schools hard hit by Proposition 13, the Moveable Museum is staffed by trained docent volunteers under the leadership of Joan Grasty, Acting Head of Education. Docents offer illustrated presentations in areas related to the school curriculum, and artifacts are provided for children to touch, observe, and question. In the two years since its inception,

the Moveable Museum has reached more than ten thousand children. Last October, the Moveable Museum was selected as the Outstanding Outreach Program for 1984 by the Los Angeles County Board of Supervisors.

The grant from National Medical Enterprises will enable the museum to expand its program to include Los Angeles's exceptional children—the vision and hearing impaired, the orthopedically handicapped, the retarded, and the psychologically disturbed. Part of the funds will be used to acquire materials appropriate for these children. The remaining money will be used to purchase a van dedicated to the program (the "moveable" in the Moveable Museum is currently supplied by volunteers' vehicles).

EXHIBITS New Activity in George C. Page Museum Fishbowl Lab

During the construction of the George C. Page Museum in 1975, a new fossil deposit was discovered where the atrium garden now stands. This deposit differed from the more than one hundred previously excavated from Rancho La Brea because it contained articulated fossil skeletons. (At the other excavations, the bones from many different animals were jumbled together due to movement within the asphalt deposits; the reconstructed skeletons on display in the Page Museum each represent the remains of many individual animals.)

In order to keep to the construction schedule, the new fossiliferous deposit was removed in twenty large

blocks, each encased in plaster of Paris for protection, to be prepared at some future date. Now that most of the fossils previously collected from the other sites in Hancock Park have been cleaned and cataloged, the staff and volunteers at the Page Museum will be devoting their attention to the preparation of the blocks from the construction site.

The center of the fishbowl lab has been remodeled accordingly, and visitors will be able to watch staff and volunteers carefully preparing the blocks as part of a living exhibit. This work, which will take several years to complete, should yield much new information about life in the Los Angeles region toward the end of the last Ice Age.

36,000 Year-Old Bison Hide at Page Museum

A portion of the tanned hide of a 36,000 year-old bison, is now on exhibit at the George C. Page Museum. The specimen is on loan from the University of Alaska Museum, Fairbanks, and is one of three such exhibits in the world on extinct large mammals from permafrost deposits.

The Steppe Bison (*Bison priscus*) was the ancestor of both types of bison (*Bison antiquus* and *Bison latifrons*) found in the Rancho La Brea deposits; it was common in Alaska and throughout Eurasia during the Ice Age and is depicted in European cave paintings. The bison on display, which was discovered during gold-mining operations near Fairbanks, was killed and partially eaten by the extinct American Lion (*Felis atrox*).

Gallery Opening Deutsch Gallery of Gem-

stones and Their Origins.

Opening May 3.

Movie Posters.

Opening May 14.

Continuing Exhibits

Animated Apatosaurus

(*Brontosaurus*).

California Condors.

Megamouth.

Mushrooms Up and Down

Los Angeles.

Recent Acquisitions: Pueblo

Pottery. Through November

15.

West Texas Cactus and

Succulents.

Animated Woolly Mammoth.

Page Museum.

ANNOUNCEMENTS Kate Sibley

Kate Sibley, the museum's new special events coordinator, has been producing special events ever since she organized her first jacks tournament in Crested Butte, Colorado, in 1970. She was involved for several years with the Denver Symphony Orchestra and later worked for the Seattle Symphony Orchestra. Ms. Sibley moved in 1980 to Telluride, Colorado, and then to Santa Fe, New Mexico, where she worked



Kate Sibley, the museum's new special events coordinator.

Dick Meier

with the National Film Preserve in producing the Telluride and Santa Fe Film Festivals. She comes to the Natural History Museum from the Museum of New Mexico, where her final project before relocating was to orchestrate that museum's seventy-fifth anniversary celebration.

Biology of the White Shark

The Southern California Academy of Sciences, one of the museum's founding organizations nearly seventy-five years ago, has published *Biology of the White Shark (Carcharodon carcharias)*, a collection of papers presented at a symposium held during the academy's annual meeting at California State University, Fullerton, in May 1983. The symposium volume includes papers on distribution, growth, vision, feeding behavior, attacks, and predator/prey strategies of the white shark. The publication may be obtained from the Southern California Academy of Sciences, Natural History Museum, 900 Exposition Boulevard, Los Angeles, CA 90007.

FREE FILMS AND GALLERY TOURS

In May and June the Tuesday film and gallery tour program will focus on gems and minerals in honor of the opening of the Alex Deutsch Gallery, *Gemstones and Their Origins*. Films and tour May 7 and June 4. The films will begin at noon in the Jean Delacour Auditorium, and tours will start at the north entrance at 1:30 p.m.

Films

Gems of the Americas color
30 minutes
This film explains the long and

tortuous process by which crystalline materials are discovered within the earth by miners and transformed by jewelers into rare gems. This film was produced by the Natural History Museum of Los Angeles County and the Gemological Institute of America.

The Rock Cycle color
22 minutes

The fundamental geologic processes whereby earth materials are formed and altered are examined in this film. The major types of rocks and the ways in which they are affected by erosion, weathering, heat, and pressure are shown through outstanding animation and dramatic photographic sequences from locations such as Yosemite, Yellowstone National Park, and Mount Saint Helens.

Tour

Gemesis: Gemstones and Their Origins

This tour will introduce you to the museum's new permanent gem exhibit, the Alex Deutsch Gallery of Gemstones and Their Origins. Gemstones are among the rarest of nature's treasures and this exhibit presents the stories of their formation in the earth, their mining by man, and their uses to society. Some special gems from the Smithsonian's collection will be on display during the opening weeks of this new gallery.

Free Films at the Page Museum

The Page Museum is open free of charge on the second Tuesday of each month, and admission to screenings of special films is also free on that day. On May 14, *Connections: Wheel of Fortune*, in which James Burke tells of ancient priest-astronomers

who knew when to plant and harvest and modern computers that see into the future, will be screened. The program on June 11 will be *Connections: Thunder in the Skies*, which depicts European man's response to a thirteenth-century Ice Age. The film will be shown at 1:30 p.m. and again at 3:30 p.m. in the Page Museum's Educational Classroom; please call the Page Museum at 213/857-6306 for further information.

EDUCATIONAL OPPORTUNITIES

Natural Basketry Workshop, Beginners, Judy Mulford, Instructor. Saturday, May 11, 1985. 9 a.m. to 4 p.m. \$20 members, \$25 nonmembers. Create a functional or sculptural basket using plaiting, twining, and weaving techniques and native California plants. All materials will be provided, but you may bring dried flowers to add special decorative motifs. Limit ten people. To register, please send your check made out to the Natural History Museum Foundation to: Education Division—Basketry, Natural History Museum, 900 Exposition Boulevard, Los Angeles, CA 90007.

MEMBERSHIP INFORMATION

Upgrade your membership to the **PATRON** (\$100) category and receive new benefits and an exciting opportunity to open doors on new horizons. Patron members receive free admission to several major natural history museums across the United States, including the Carnegie Museum in Pittsburgh, the California Academy of Science in San Francisco, the Field Museum in Chicago,

and the Denver Museum of Natural History. Patron members also receive special discounts at these museums' shops. Other benefits include:

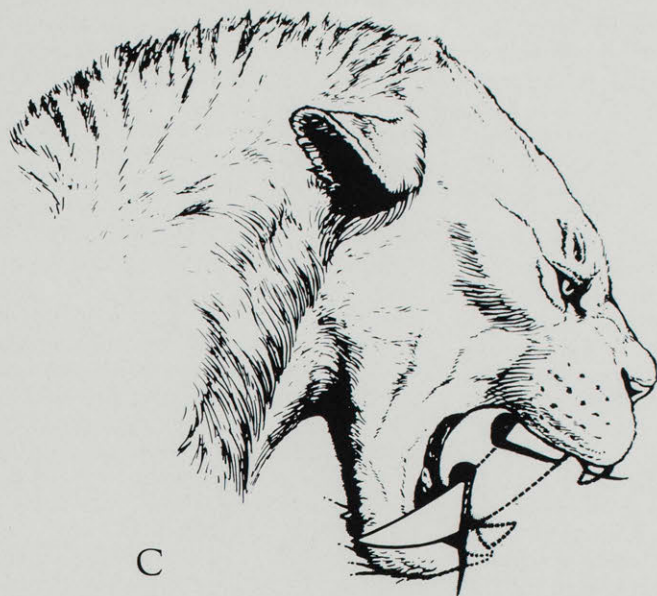
- Invitation to exclusive evening previews of new exhibits, such as the upcoming Maya: Treasures of an Ancient Civilization.
- A free copy of *Rancho La Brea: Treasures of the Tar Pits*. Upgrade your membership now and receive a free Olympic commemorative poster. Please call Becky Chapman at 213/744-3426 for more information.

GENERAL INFORMATION

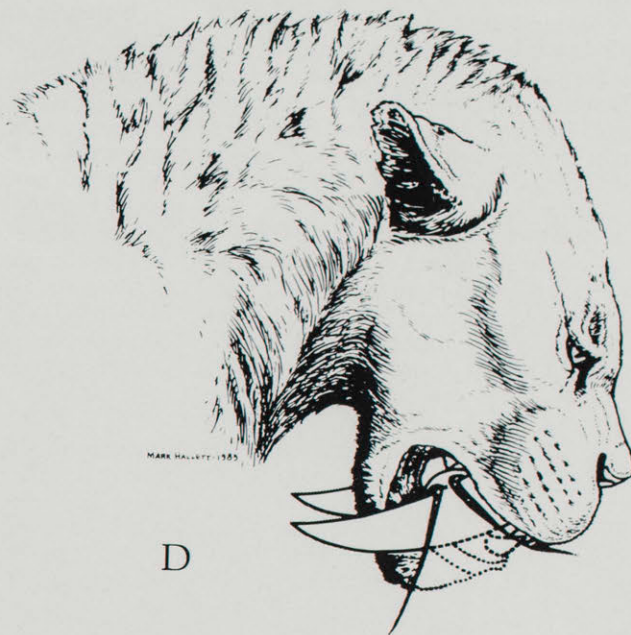
The Natural History Museum, located at 900 Exposition Boulevard, Exposition Park, Los Angeles, California 90007, is open from 10 a.m. until 5 p.m., Tuesday through Sunday. The museum is closed Mondays, Thanksgiving, Christmas, and New Year's Day. Admission is \$1.50 for adults and \$.75 for students and senior citizens; children under 5 are admitted free. Admission is free on the first Tuesday of each month. For further information on museum activities and future events, please call the Membership Office, 213/744-3426.

The Page Museum of La Brea Discoveries, located at 5801 Wilshire Boulevard, Hancock Park, Los Angeles, California 90036, is open from 10 a.m. until 5 p.m., Tuesday through Sunday. The museum is closed Mondays, Thanksgiving, Christmas, and New Year's Day. Admission is \$1.50 for adults and \$.75 for students and senior citizens; children under 5 are admitted free. Admission is free on the second Tuesday of each month. For further information, please call 213/857-6311.

primarily to hold the jaw in place. Further closure of the mouth is accomplished by depressing the head against the stationary jaw. C. Continuation of the shear-bite using the head-depressing muscles. D. The shear-bite is now complete except for a final jerk to remove the flesh-fold. Drawings by Mark Hallett.



C



D

downward around the joint with the first vertebra of the neck. This was powerful support for *Smilodon* having stabbed or slashed since these muscles were positioned exactly right for a stabbing or a slashing action with sabers. I also had to agree that the geometry of the jaw-closing mechanism appeared to support the idea that the mechanism was rather weak, especially when the mouth was opened wide. But several other features muddled the issue even more, particularly the fact that the front portion of the lower jaw was very stoutly constructed. If *Smilodon* stabbed or slashed, the lower jaw could not be used in such activity, but would simply be drawn out of the way and later used to help in tearing up and chewing flesh. Why should it be so much stronger than the jaw of a similar-sized lion if it were used so much less? I also saw that the lower canine (which is proportionately much smaller than in living cats) was quite sharp and had a finely serrate ridge. If it served a biting function in sabertooths, I would have expected it to be closer in size to the lower canine of true cats. But, if the lower canine were not used for biting, why was it sharp, and why did it have a saw-tooth edge for cutting? Looking at the flange on the chin (for which a variety of functions had been suggested), I saw that it formed two strong ridges at the front of the jaw, but very weak ones along the bottom. At the time this was interesting, but it didn't seem to relate to the problem I was trying to solve.

So far I had gotten nowhere. Some things fit a stabbing or slashing attack

and argued against a biting attack; others did just the opposite. Then I took a look at the geometry of the skull to see if it would yield any clues. It gave me *more* than clues!

In the drawing of the *Smilodon* skull with jaws at maximum gape on page 18, A is the point about which the head-depressing muscles would rotate the skull, and B is the tip of the saber. For efficient initial penetration of the sabers, the teeth need to strike the prey at right angles to their long axes at the instant of contact as shown by the arrow from B to C. This is precisely what would happen in *Smilodon*, and, at first glance, the geometry is perfect for either stabbing or slashing. However, if one looks at additional geometric relationships during rotation of the head, a different picture emerges. The tip of the saber would travel along the dashed arc D-B, while the tip of the lower jaw would travel along the dotted arc F-G. During stabbing or slashing, the body of a prey animal would have to be well inside the dashed arc D-B for the sabers to strike more than a glancing blow. But if any part extended inside the dotted arc F-G, the lower jaw would strike first, and the mouth of the attacking sabertoothed cat would be rather abruptly closed. The two curves are so close together that it would have been impossible to drive the sabers through the hide of a prey animal by means of a stab or slash.

Now that the geometry had shown that stabbing or slashing was impossible, I had to see if the sabers could have played a part in biting. I realized that

there was another possible way to close a mouth besides moving the lower jaw upward against a more or less stationary cranium. The cranium could be moved downward against a stationary lower jaw. But how to keep the lower jaw stationary? The same system of muscles and levers that indicated a rather weak bite at full gape would not be strong enough to oppose the force of the cranium being depressed. The lower jaw would have to be stabilized in some other way, perhaps by pressing it against the body of the animal being attacked. Then the forward-projecting ridges formed by the chin flanges would help to hold the jaw in place.

This realization allowed me to construct an explanation that seemed to pull together all of *Smilodon's* apparently contradictory features, including some not mentioned here. After the sabertooth pulled down its prey with its massive forelimbs, it would bite a nonbony part of the animal, probably the unprotected abdomen. First the sabertooth's gaping mouth would be pressed against the body and would start to close, producing a fold of flesh in front of the mouth. By the time the tips of the canine teeth were about to puncture the fleshfold, the jaw-closing muscles could no longer overcome the increasing resistance to closure. The head-depressing muscles took over, pushing the cranium down against the mandible, which was held in place by the jaw-elevating muscles and by pressing the flanges of the front part of the lower jaw against the prey. The short but sharp lower canines would serve primarily to

hold the fleshfold in place.

As the mouth closed, the back edges of the sabers would progressively shear through the sides of a fleshfold anchored by the lower canines. At the end of the shear-bite, the greatly enlarged and interlocking incisors at the front of the mouth would punch through the front edges of the fleshfold and the flesh could easily be removed with a jerk. Sort of a "tear along dotted line" if you will. While the wound might not be immediately fatal, shock and loss of blood would soon kill the injured prey.

Now I could put together a logical picture from the pieces I had. There no longer was any problem in evolving stabbing or slashing from biting ancestors because it didn't happen. The powerful head-depressing muscles, the stoutly constructed lower jaw, the knifelike sabers, the weak jaw-closing apparatus, the anterior ridges formed by the lower jaw flanges, the short but sharp lower canines, and other features could all be explained by the shear-bite theory.

A survey of other sabertoothed mammals showed that all could have used a

The Komodo dragon kills deer and boar by ambushing the animals, pulling them down with their jaws since their forelimbs lack grasping capabilities, and biting open the abdomen.

shear-bite even though the details must have been different for some. But I was uncomfortable because there is no living mammal that kills using an ambush/shear-bite to the abdomen technique and none that possesses similar teeth. We always feel better if there is a living analog we can point to for confirmation.

Then, in 1980, I attended the annual meetings of the Society of Vertebrate Paleontology in Gainesville, Florida. The after-dinner speaker at the society's banquet was Dr. Walter Auffenberg, a herpetologist at the University of Florida. He described his studies on the behavior and morphology of the Komodo dragon, a large (up to ten feet long and weighing as much as one hundred thirty pounds), carnivorous monitor lizard living on several islands in the East Indies. (I'll bet

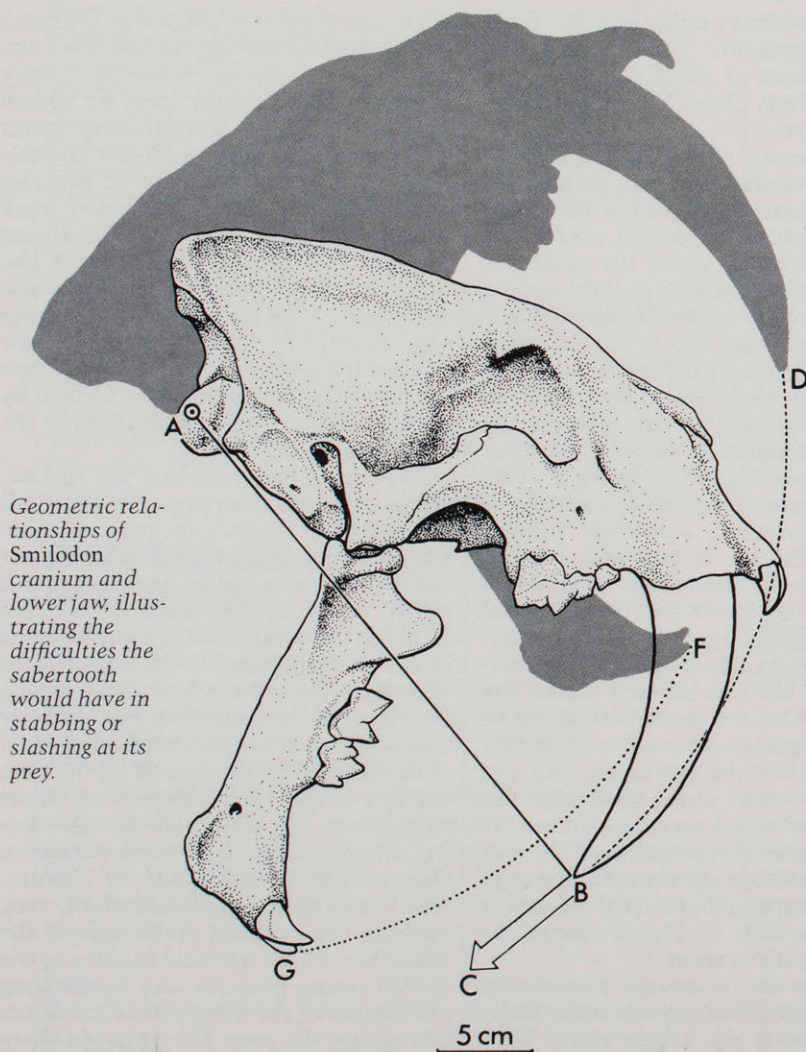
you were beginning to wonder what the "Dragons" in my title had to do with sabertooths.) They kill deer and boar by ambushing the animals, pulling them down with their jaws since their forelimbs lack grasping capabilities, and biting open the abdomen. Just as it was beginning to sink in that this was similar to what I had suspected for *Smilodon*, Dr. Auffenberg showed a picture of the teeth. While they were smaller, more numerous, and present in both the upper and lower jaws, they were almost exact copies of *Smilodon* sabers! I now had my modern analog.

Even more interesting facts were to come. Naturally, I began to read up on Komodo dragons and their fossil record. Dr. D. A. Hooijer of the Rijksmuseum van Natuurlijke Historie, Netherlands, had described Pleistocene Komodo dragon remains from one of the islands they currently inhabit. In the same fossil deposits only two potential kinds of prey animals were found, both small mastodonts similar to elephants. Thus, Pleistocene ancestors of the Komodo dragon may have had a diet similar to that of at least one of the extinct sabertooths. And in Australia, the only temperate continent never inhabited by sabertoothed mammals, there are the fossilized remains of very similar large monitor lizards that attained lengths of as much as twenty-three feet. Perhaps these creatures were, in essence, the sabertooths of Australia—perhaps sabertoothed mammals never evolved there because this particular niche was already occupied.

It may seem as though this tale is told, that all the pieces fit into their proper places—but it isn't, not by a long shot. Of course, I think that my theory of saber use is correct, otherwise I wouldn't be writing about it. But I must remember that in the past many other researchers have written up different conclusions in the belief that they were correct. Some of our differences are based on different interpretations of the same observations and others on the fact that I had new information—a few more pieces of the puzzle—which were not known when the other researchers did their work.

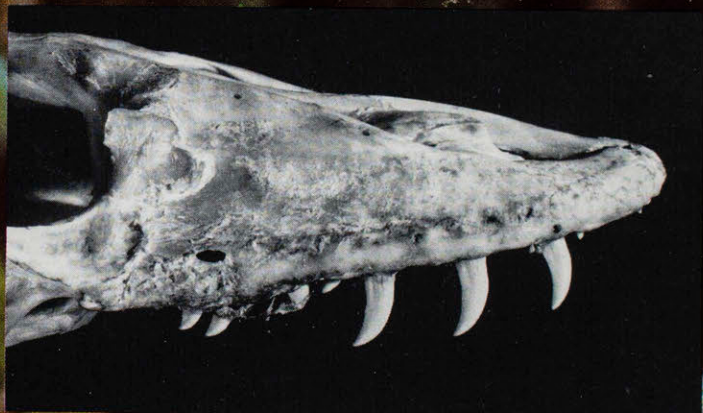
Paleontology is an active science; new information and new methods of study are constantly being discovered. Even presuming that I have interpreted the information I worked with in a logical manner, future finds and studies could easily result in a different interpretation of the puzzle of the curious beasts we call sabertooths.

William A. Akersten, formerly Curator of Vertebrate Paleontology and Curator of Rancho La Brea from 1975 to 1982, is now Curator of Vertebrate Paleontology and Associate Professor at the Idaho Museum of Natural History.



Geometric relationships of *Smilodon* cranium and lower jaw, illustrating the difficulties the sabertooth would have in stabbing or slashing at its prey.

*A reptilian analog for
sabertoothed mam-
mals! A mug shot of
the lovely Komodo
dragon. Photo cour-
tesy of Dr. Walter
Auffenberg. Inset:
Komodo dragon
cranium showing
multiple sets of saber
teeth.*



In 1911 the United States, Great Britain, Russia, and Japan approved an international treaty that ended 170 years of unregulated exploitation of the sea otter in the North Pacific Ocean. Approximately one-half million sea otters, *Enhydra lutris*, had been killed between 1741 and 1911 by commercial hunters and coastal Indians, driving the sea otter dangerously close to extinction.

Before the first Europeans arrived, however, native peoples living along the Pacific Coast of North America hunted sea otters for food and skins. At many local sites, hunting pressure by early man reduced the number of sea otters, which are important predators on sea urchins and other invertebrate herbivores, and dramatically altered the near-shore community. The result was either luxuriant kelp forests or barren, sea urchin-dominated patches.

Scientists have been using ecological and archaeological data to piece together patterns of biological community change during prehistoric times. Interaction between early man and sea otters in the Aleutian Islands off the coast of Alaska have been especially well described.

The Aleutian Islands, stretching eleven hundred miles between the Bering Sea and the North Pacific Ocean, were formed by volcanic activity over the last seventy million years. Peoples from Alaska gradually occupied this archipelago from the mainland, and the western islands were populated about eight thousand years ago. Aleutian Island peoples, or Aleuts, depended upon marine animals for food because the islands lacked terrestrial vertebrates until the recent introductions of foxes, rats, mice, and ground squirrels. Aleuts collected sea urchins, mussels, chitons, limpets, and crabs from the intertidal zone and hunted sea otters, sea lions, fish, and harbor seals. The marine vertebrates provided food, pelts for warm clothing in harsh weather, and other raw materials for jewelry, clothing, fishing gear, and religious items.

Archaeological evidence from Aleut middens (refuse heaps that accumulated from cooking and other activities of the villagers) indicates that sea otters were the mammals the Aleuts hunted most. These early Aleutian Islanders hunted sea otters from skin boats, called *baidarkas* by Russian explorers and *kayaks* by Aleuts, made by lashing wood or whalebone strips together with whale or sea lion sinews and then covered with seal or sea lion skins that were oiled and tightly sewn.

During summer hunting periods, Aleutian hunters, in as many as twenty single- or double-hole kayaks, set out from their village for the hunting ground. The boats advanced quietly in a line or

Otters, Urchins, and Aleuts

by JAMES H. PETERSEN

Was early man a factor in caus-

ing dramatic changes in Pacific

Coast biological communities?

Examinations of the interrela-

tionship between sea otters, sea

urchins, kelp beds, and early

man are disproving arguments

that pre-European biological

communities were always

balanced and stable.

semicircle until the hunters sighted an otter; they then surrounded the otter and speared it when it came to the surface to breathe. Hunting otters involved specific rituals because the Aleuts regarded the animals as transformed human beings—a hunter often carried talismans collected from the sea, believing that these

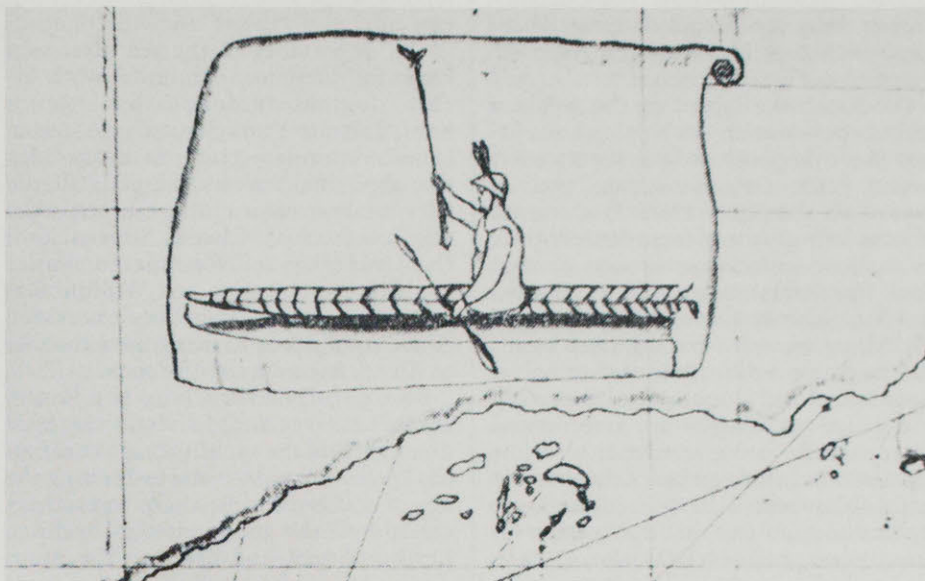
objects attracted otters and improved the hunter's success.

Beginning with the Russian-commissioned voyage of Vitus Bering and Aleksei Chirikov to the Aleutian Islands in 1741, sea otters became important to Russian, Spanish, British, and American fur traders. Most merchants depended upon trade with the Aleuts or coastal Indians for otter pelts, although some vessels hired or enslaved Indians to collect the pelts required to complete their cargo.

Russian traders concentrated their activities on the Aleutian and Alaskan coasts, although they came as far south as Fort Ross, California. The Spanish sea otter trade was centered in southern California and northern Baja California. British and American merchants traded clothing, metal tools, mirrors, glass beads, and other items for sea otter pelts with Indians along the shores of present-day British Columbia, Washington, Oregon, and northern California. Many of the British and American pelts were sold to the Chinese, especially through the trading centers of Canton and Macao. During the peak trading year of 1805–06, 17,445 otter pelts were exported to China. The numbers of pelts sent to China declined yearly after 1806 until only 300 pelts were traded in 1832.

As keystone predators in the shallow subtidal zone, sea otters regulate herbivore populations and therefore indirectly control algal abundance. Herbivores such as sea urchins, limpets, and chitons are favorite prey collected and eaten by otters. Sea otters also occasionally eat fish, mussels, crabs, clams, octopus, snails, and various other animals. A diving otter pries off bottom-dwelling organisms, carries them to the surface under one foreleg, and places them on its stomach as it floats on its back. An otter opens hard-shelled food items such as clams by striking them against one another or against a rock carried on the stomach as an anvil or hammer. It then consumes the soft inner part of the invertebrate and discards the shell. All sea otters require large amounts of food for survival—up to 30 percent of their body weight per day for juveniles. In the Seattle Zoo, the average daily intake of a thirty-nine pound captive sea otter named Susie was nine pounds, although she sometimes ate as little as two pounds and as much as sixteen pounds per day.

Because of their voracious appetites and effective foraging, sea otters may affect the population size of preferred prey species, particularly sea urchins. Selection of different types of food by sea otters in the nearshore zone depends upon the relative abundance of food items, especially sea urchins, in an area. When sea urchins and other bottom-



dwelling herbivores are abundant, sea otters eat these prey exclusively and spend only a few hours a day foraging; the remainder of the day is spent resting, grooming, traveling to new areas, and sleeping. An otter can find and consume one urchin in about two minutes when urchins are numerous and may remove over sixty urchins during its daily two-hour foraging period. In a square mile of urchin-dominated habitat populated with ten to fifteen sea otters (a common density), the otters may eat up to nine hundred urchins in one day. Urchin density is drastically reduced by such intense predation. Fish become important prey of otters, and daily foraging time increases when sea urchins are rare and hard to find.

By crawling over the rocky bottom and scraping algae from the rocks' surface



Tom Myers

Top: The Aleut hunter and map were drawn by Sven Waxel, second in command on Vitus Bering's 1741 expedition.

Bottom: Sea otters spend most of their life in nearshore waters, rarely coming ashore and rarely venturing more than a few miles from the coast. Otters prefer areas where the water is thirty to ninety feet deep. Sea otters are currently protected by the Marine

Mammal Protection Act; however, aboriginal peoples of Alaska are allowed to harvest otters for subsistence purposes. Sharks, killer whales, and bald eagles are the sea otter's only predators besides man, but their effect on otter populations is small.

with their jaws, sea urchins limit the density and distribution of many species of algae. Soft, fleshy algae such as kelp and green algae are especially susceptible to urchin grazing. Coralline algae, which are tough and have relatively low nutritional values, are not generally eaten by grazing urchins. Since kelp and other fleshy algae compete with coralline algae for attachment space on rocks, coralline species often form dense algal mats or encrusting pavements where urchins have removed competitive algal species.

The interactions between sea otters and sea urchins can therefore alter the composition of the nearshore community. Massive kelp forests exist in areas where sea otter foraging maintains sea urchin density below a critical level. However, if sea urchin density is not limited by otter predation or other mechanisms, urchin density increases, and kelp beds do not develop because of the

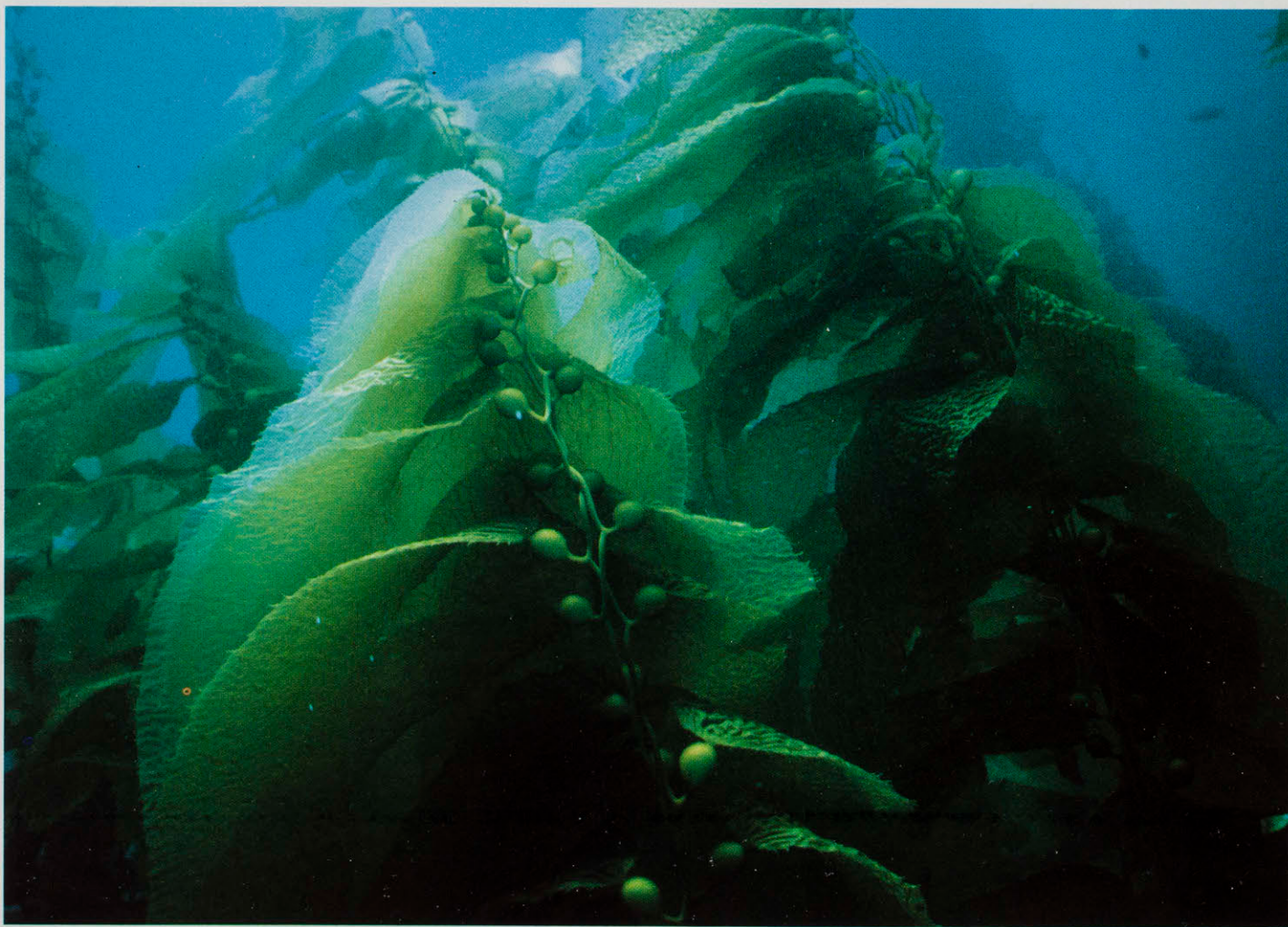
intense grazing pressure. High density urchin areas are devoid of most fleshy algae including kelp, and are often referred to as "barren grounds."

On Amchitka Island at the western end of the Aleutian Archipelago, sea otters have been abundant for at least twenty years, with an estimated population of six thousand otters. Five species of large kelp grow and form dense forests in shallow rocky areas around this island. In contrast, sea otters on Shemya and Attu islands, also on the west end of the Aleutians, were exterminated by fur traders; there are currently 350 otters on Attu Island and none on Shemya. Kelp and other macroalgae are rare around these islands, being restricted to a few species in isolated patches. Kelp beds and urchin-dominated barren grounds are stable communities that may persist for many years until severe storms, disease, or predation upset the community

relationships.

The importance of the sea otter as a keystone predator, combined with archaeological evidence that Aleuts hunted otters throughout the Aleutian Islands, stimulated interest in the idea that aboriginal hunters indirectly altered the nearshore community, especially the algal community. Charles Simenstad of the University of Washington, James Estes of the U.S. Fish and Wildlife Service, and their co-workers excavated Aleutian middens to investigate the diet of Aleuts from different islands.

By carefully identifying the bones, shells, and sea urchin tests (the hard outer shell of the urchin) found in different levels of a midden and estimating the age of midden levels, these researchers calculated the proportion of urchins, limpets, otters, and fishes in the Aleut diet and the relative abundance of these



Tom Eville

*Thick kelp forests provide a habitat for a diverse community of mollusks, echinoderms, crustaceans, algae, and fishes. Several species of kelp grow along the West Coast, including the giant kelp (*Macrocystis pyrifera*) photographed along the coast of southern California.*

species in the foraging area of the Aleuts through the last twenty-five hundred years.

Midden contents cannot reveal to us the total diet of the Aleuts since not all foods leave traces. For example, some fish bones are too fragile to survive burying in the midden, and soft-bodied mollusks such as octopus have no calcified shell or test. However, most skeletal, calcareous, and shell remains are well preserved.

Recent midden excavations on Amchitka Island demonstrate that sea otters and fish made up a large part of the Aleut diet for several centuries beginning about twenty-five hundred years ago. Sea otter and fish bones are relatively rare in Aleut midden layers that are two thousand years old, and invertebrate shells and tests become more abundant, indicating a change in the Aleut diet. Continual Aleut hunting of sea otters on

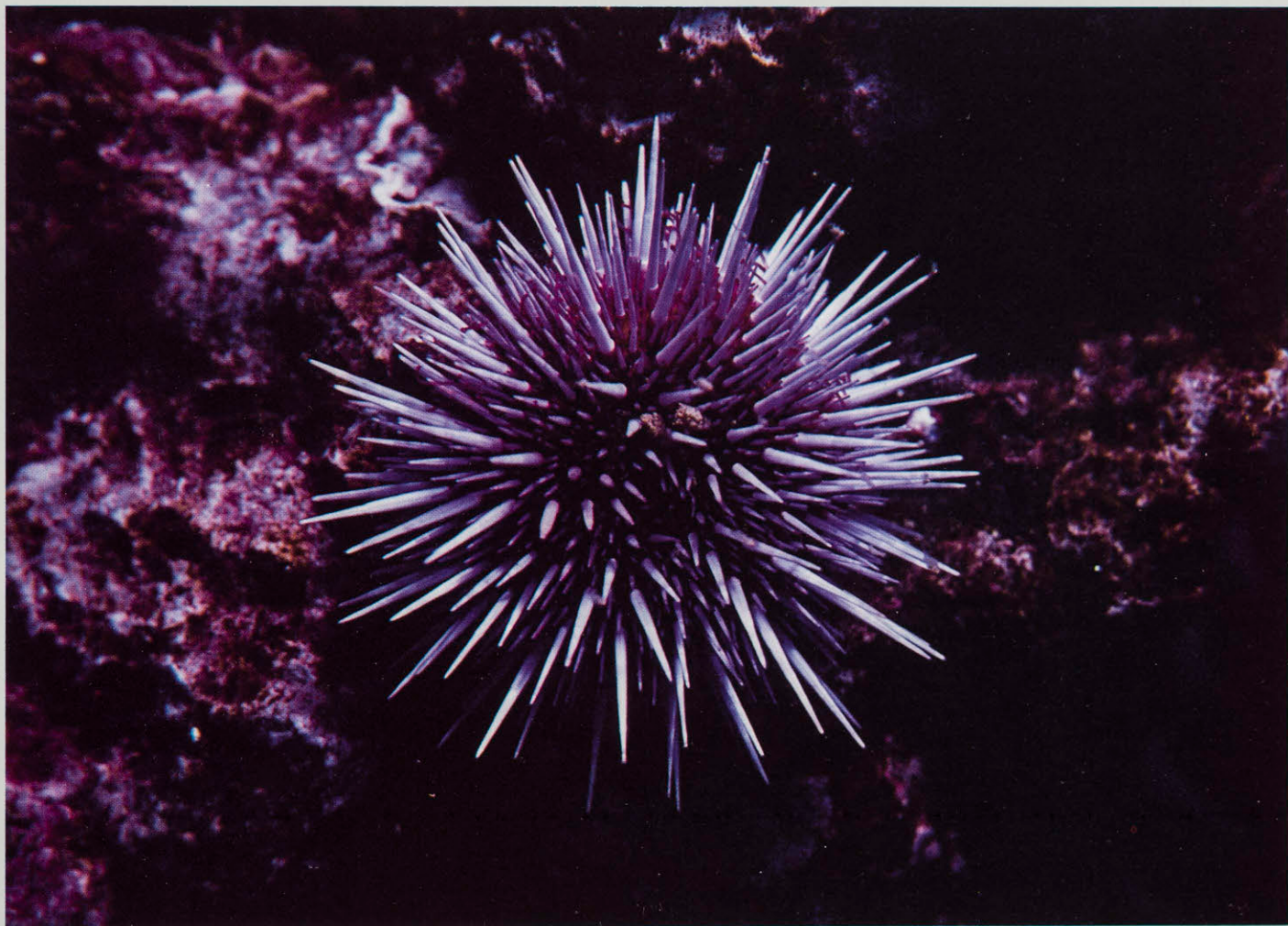
Amchitka Island presumably caused local extinctions of otter populations. As otters became rarer and more difficult to find, Aleuts began foraging for alternate food items, specifically invertebrates. Populations of sea urchins and other herbivores increased and migrated into the shallow littoral zone when the predaceous otters were killed off.

Midden contents may also be used to describe the composition of the near-shore marine community through time. The oldest Aleut midden strata on Amchitka Island have a low frequency of urchin tests and abundant otter and fish bones. This pattern and modern studies on the sea urchin-algal relationships are good evidence that shallow water communities during these periods were characterized by many otters, few invertebrate herbivores, and extensive kelp forests. Urchin tests and limpet shells are predominant in the middle

strata, while bones of sea otters, harbor seals, and fish are relatively uncommon at these levels.

After overhunting by the Aleuts caused local extinction of the sea otter populations around some islands, the nearshore community was dominated by dense urchin populations and abundant coralline algae. The diverse community of animals commonly associated with kelp forests—including kelp bed fishes, which were important food species during deposition of the oldest midden strata—also disappeared with the kelp plants.

In contrast to the Aleuts, the first Indians arriving in California over ten thousand years ago did not initially rely heavily upon the marine environment for food or raw materials. Grinding implements, spear points, and other stone artifacts found at the campsites of these



Tom Eville

Purple sea urchins (Strongylocentrotus purpuratus) and other urchin species can form dense aggregations on rocky bottoms, grazing on attached plants and also catching drift algae for food. Purple coralline algae often encrust the rocks in urchin-dominated areas because these algae are largely resistant to the intense grazing pressure.

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early Indians suggest that they had a gathering economy supplemented by hunting terrestrial animals and waterfowl. As their population grew, the Indians established permanent settlements; land-based resources became inadequate, and marine resources became important for food and trade. Channel Island middens and artifacts show that Indians who lived there as far back as seven thousand years ago were fishing, collecting abalone, and hunting various marine mammals, including dolphins, porpoises, seals, sea lions, and sea otters.

What effect Indians in California had on sea otter populations and the near-shore community is uncertain, although relationships were probably similar to those in the Aleutians. Phillip Walker from the University of California at Santa Barbara believes that increased trade between coastal and inland Indians by about A.D. 1100 may have caused increased hunting of sea otters, a valuable trade commodity. This intensified hunting pressure may have drastically reduced sea otter populations at some localities. Walker's midden studies demonstrate that otter bones are much more common on San Miguel Island than in mainland coast sites, suggesting that otters may have been hunted to extinction on the mainland side of Santa Barbara Channel. Use of the bow and arrow became common about this time and this new hunting technique may have increased the Indians' success and efficiency at the expense of the sea otter. Pre-Hispanic Indians undoubtedly killed many otters and also exploited the kelp bed habitat for many invertebrates and fishes, but the specific effects of these activities on nearshore communities is not fully understood.

South of Point Conception, Indians also ate California sheephead, a large, predaceous fish particularly abundant around kelp beds. Sheephead consume many sea urchins; thus, kelp distribution and abundance may have been indirectly regulated by Indian fishing of these predators. Spiny lobsters are also important predators on purple and red sea urchins, preferring medium-sized sea urchins, which are easier for lobsters to handle. Heavy fishing pressure on spiny lobster and California sheephead in the Southern California Bight in recent years may have caused urchin populations to increase, creating local episodes of destructive urchin grazing on kelp beds.

Southern populations of sea otters are expanding, with some dramatic effects on nearshore algae. Sea otters once ranged as far south as Cedros Island off Baja California, where Spanish missionaries reported many otters in 1733. Following the intense fur hunting of otters in the eighteenth and nineteenth centuries, sea otters were once thought

to be extinct south of Prince William Sound, Alaska. In 1938 a small otter population was discovered at Big Sur on the central California coast. From 1938 this population spread steadily, reaching Point Santa Cruz in the north and Pismo Beach in the south, a range of 180 coastal miles; in the last decade, however, this population has not grown significantly and now totals around thirteen hundred individuals.

Sea otters have also been transplanted from Alaskan waters to several southern sites during the last twenty years with hopes of reestablishing populations that were wiped out by fur hunters. For example, eighty-nine otters were moved to the Bunsby Islands west of Vancouver Island between 1969 and 1972. Aerial surveys in 1977 and 1978 showed fifty-five individuals in the original transplant area and a second colony of fifteen otters near Nootka Sound. Observations before and after otter introduction confirmed that otters reduced the number of red urchins and restricted urchins to crevices or beneath large boulders within sea otter foraging grounds. Before reintroduction of the otters, kelp was found only above the sea urchin zone and on top of large boulders, but several species of kelp formed productive beds throughout the shallow subtidal zone after otter transplantation.

The growth of sea otter populations in Alaska and along the West Coast of North America has prompted debates between environmentalists and commercial fishermen over otter control programs and management of nearshore resources. A central issue in these debates has been the question of how to define the "natural" nearshore community. Are kelp beds with sea otters a more typical community than sea urchin barren grounds?

Recent studies are disproving arguments that pre-European communities were always balanced and stable. In many cases, early man was a very effective predator and forager, causing some dramatic changes in biological communities. These changes, including alternation between kelp forests and barren grounds, often occurred relatively rapidly and resulted in new species assemblages that could persist for long periods. Further integration of anthropological and biological studies should give us a better understanding of the complex relationships between early man, key-stone predators, and other species in the biological community.

Jim Petersen is a marine biologist at the Natural History Museum of Los Angeles County. He has studied marine ecology in Australia, Oregon, and California, and is currently working on the ecology of larval fishes and zooplankton in the Southern California Bight.

How to Photograph Butterflies

by JAMES ALLEN

Photographs by the author





Malachite (Siproeta stelenes). This Malachite was hanging under a leaf during a spring shower. I photographed it with flash and extension tubes on my normal lens. The background is black because the foliage behind the subject was too distant to receive enough light to record an image.

Previous page: Western Tiger Swallowtail (Pterourus rutulus). After catching this Western Tiger Swallowtail in the morning, I placed it in a plastic container and lowered its body temperature with a five-minute interlude in the refrigerator. After placing the butterfly on an iris in my den, I used the modeling light on my strobe to provide heat and light to induce its wings to open. The exposure was made with a flash.

I think butterflies enjoy teasing photographers. They flutter and they fly, never stopping for more than a few moments. With their magnificent color patterns and delicate wing structure, they entice, they tantalize, they tempt us to capture them on film, and then, at the slightest approach, they are gone. Photographing butterflies can, indeed, be an exercise in frustration.

Success in photographing wildlife, including insects, largely depends on knowing your subject. With an understanding of a few basic facts about their eating habits, temperature requirements, and sensitivity to various environmental stimuli (wind, light, rain, and so on), you can gain virtual control of these elusive creatures and take beautiful photographs of them.

The most significant single fact that makes butterfly photography so easy is their response to temperature changes. All butterflies, no matter what their size, require an air temperature of between 56 and 60 degrees Fahrenheit or sunshine

strong enough to raise their body temperature so that they can initiate controlled flight. If the mercury falls below this level or they can't garner enough energy from the sun, they simply can't fly. If you catch a butterfly and place it in a cool environment it becomes motionless, folding its wings over its body in the dorsal position, revealing the color and patterns of the underside of the wings. When the butterfly is in this motionless posture, photographing it is quite easy.

Generally, however, butterflies are much more impressive with their wings wide open, and it is this brilliant display of color that photographers will want to capture. This can be accomplished by understanding that warmth plays a crucial role in the insects' survival. Butterflies are more vulnerable to predators if they are trapped on the ground when it is too cold to take flight. When sunlight strikes their folded wings—which are actually very effective solar panels—most butterflies will instinctively open their wings to gather warmth and to raise

their body temperature. Usually butterflies remain perfectly still as they bask in the sun. Photographic advantage can be taken of this to capture the full wingspread before the tiny wing muscles are ready to initiate flight.

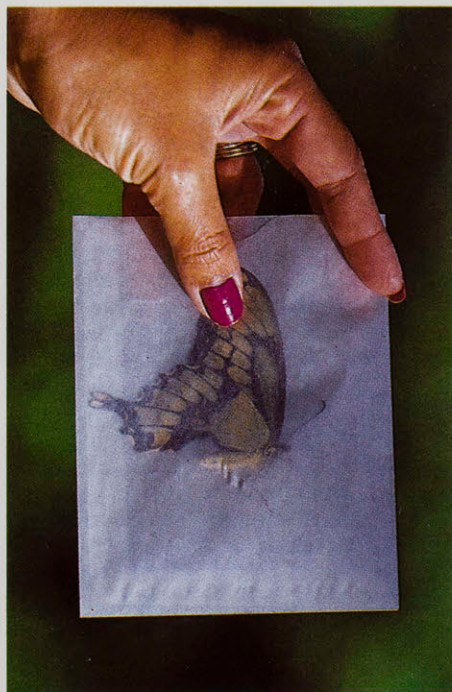
If you intend to capture butterflies for controlled studio photography, you will have to have a butterfly net. There are several types available, including a collapsible variety that can be easily packed into a suitcase for use away from home. Nets with a larger diameter opening (eighteen inches) will help you capture the erratically flying butterflies. The handle, usually about three feet long, can be extended in some models to aid in pursuing the higher flying insects.

Armed with a net, your next step is to locate the species you want. Butterflies occupy virtually every type of environmental niche from the Arctic tundra to the Tropics. In southern California they inhabit the mountains, deserts, coastal dunes, riverbeds, fields, urban parks, and backyards. Most species can be seen

Spicebush Swallowtail (*Pterourus troilus*). This Spicebush Swallowtail spent a cool night in a plastic container before being placed on a flower at dawn and photographed in the early morning light.



Bottom: A Giant Swallowtail (*Heracles chresphontes*) is confined in a glassine envelope to protect its wings from damage. Usually butterflies try to escape from their containers by vigorously flapping their wings. To prevent broken wings, it is best to immobilize the captive. After I take my photographs, I always release the insects back to the wild.



from early spring until late autumn. A few, such as the Monarch and West Coast Lady, may be observed all year long in the more temperate parts of the state. Specific sites that have numerous species include Eaton Canyon Nature Center (Pasadena), Placerita Canyon Nature Center (Newhall), Tapia Park (Calabasas), San Gabriel Canyon (north of Azusa), Whittier Narrows Nature Center (South El Monte), and Lake Sherwood (Westlake). More detailed information can be obtained from the book *Butterflies of Southern California*, by Thomas and John Emmel (published by the Natural History Museum of Los Angeles County and available at the museum bookstore).

Once you have successfully captured a live specimen, gently remove the butterfly from the net, holding its wings together in the dorsal position. Insert the specimen into a glassine envelope and place it in a cup or box atop ice in an ice-filled cooler. The envelope will keep the butterfly from flapping and possibly damaging a wing, and the cup will pro-

tect it from direct contact with the ice. An environment that is too cold could prove fatal. On the other hand, never put butterflies in a glass jar and leave them in the sun; they will surely die. Very small species, such as skippers and blues, can die in minutes if they overheat. The cramped quarters of the glassine envelope will not harm the butterfly at all if you handle the envelope gently. Because butterflies are diurnal and active in the light of day, it is best to keep the cooler closed and dark to ensure inactivity, again with the objective of protecting the very breakable wings.

Once you are at home, store the butterflies until you are ready to photograph them. If the outdoor temperature is cool (below 60 degrees), they can be placed in an opaque plastic container and left outside in the shade or in a garage. If it is too warm, you can store the butterflies for a few days in the refrigerator (never the freezer).

You can either photograph your captives indoors or outside. If you choose to



El Segundo Blue (Euphilotes batoides allyni). The El Segundo Blue butterfly is the size of a dime. I used two extension tubes and two flashes to photograph this elusive subject in the wild. Despite the wind, the image is sharp because the brief burst of light stopped all motion.

Page 29: Blue Pansy (Junonia orithyia). After a twenty-minute chase across an open field in China, I finally was able to photograph this Blue Pansy. The wing-tips are not sharp because I was not using a flash, and the available light only permitted an f/8 aperture.

shoot them outside, keep the inactive butterflies overnight in their container, and take them out in the early morning light and place them on a flower or leaf. The cool morning temperature will keep the subjects from moving. You can then shoot them with their wings folded, and when the sun rises and strikes the wings, you can take more photographs of them open.

Conduct your indoor photo session at night or in a windowless room. Butterflies will fly toward any light they detect; to maintain as much control as possible, they should not be tempted to leave the spot where the camera is focused. It is best to keep the temperature in your studio low.

Some photographers place the butterfly on a leaf or twig with a plain blue or green background. This seems too posed, too manipulated to me. I prefer a more natural appearance. Potted flowers, ferns, palms, and other plants can be arranged on a table to give the impression of a natural botanical community.

Selection of plants for the foreground and background is important: they should approximate those in the native habitat of the butterfly. An unnatural choice of plants may produce a visually pleasing photograph, but the biologist or knowledgeable gardener will be troubled by the disharmony and obvious contrivance.

Position the butterfly in the foreground. When you focus on the subject, the foliage in the background goes out of focus, providing a mottled green contrast to the sharp detail in the wings and body of the insect. This precisely duplicates photography in the field.

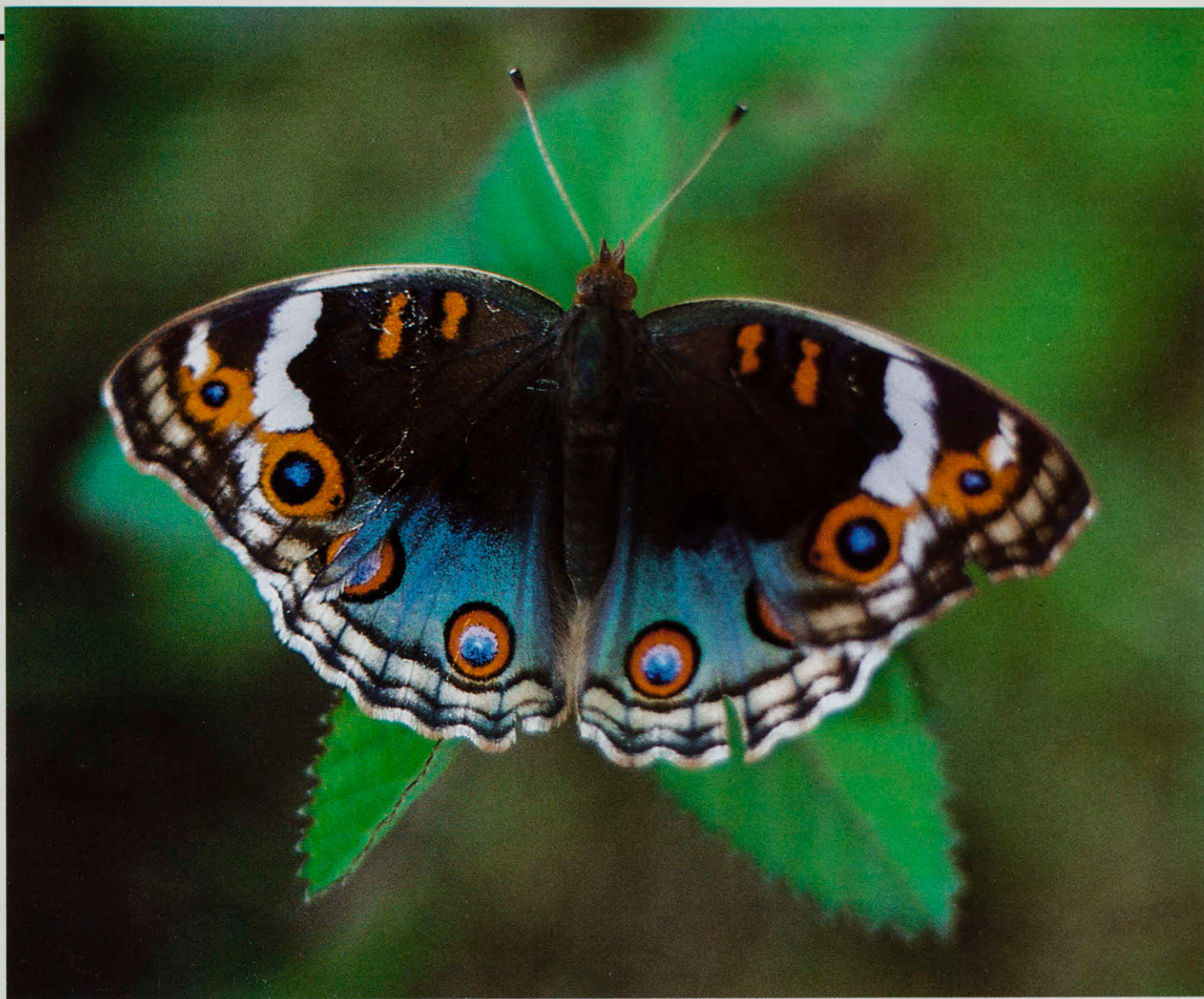
The light and heat from a photoflood lamp will usually be enough to entice the butterfly to open its wings. This is especially effective in the predawn night because the natural biorhythm of the insect is ready to respond to the morning light. Keep in mind that some species, such as sulphurs, rarely bask with open wings for more than a very brief instant.

Sometimes capturing butterflies and bringing them home is not practical or

even desirable. Photography in the field can be quite rewarding if you anticipate what will come up and prepare for it.

Most butterflies are associated with specific plants. By recognizing these food plants and by knowing the time of year the adult flies, you can usually find a particular species. Since butterflies generally cling to the underside of leaves overnight, they can be photographed in the early morning in this motionless state simply by using a tripod and taking a daylight reading from the through-the-lens meter of your camera. This presumes, of course, that there is no wind.

Wind can be a big problem. If the air is too turbulent, butterflies will not fly at all. Light or moderate breezes don't inhibit their flight, but photography becomes extremely difficult because even at rest their wings are in motion. The fast shutter speed that you will need to freeze this movement necessitates a large lens aperture to compensate for light lost. However, depth of field will be lost, and with small butterflies you need all the



depth of field possible. The only solution is to use supplemental lighting.

Since butterflies are sensitive to movement, stalk them slowly. Sudden movements startle them. Try not to disturb the vegetation near them as you get close. If possible, do not silhouette yourself against the sky (from their perspective), but close in from a lowered position. If a specimen insists on flying away from you no matter how hard you try to approach it, follow it. Even butterflies get tired. They cannot continue flying indefinitely without a rest period. When I was in China, I pursued a Blue Pansy butterfly across an open field for twenty minutes before I wore it out. I then shot an entire roll while it basked in the sun and posed for me.

THE EQUIPMENT

To create sharp, pristine images of butterflies on film, a single lens reflex camera is essential. 35mm cameras are the most practical, although medium and

large formats may also be used.

Macro lenses, such as a 55mm or 90mm macro, are excellent for close focusing. Close-focusing telephoto lenses also work well. Extension tubes and bellows are alternatives you may use in conjunction with normal photographic lenses. Many photographers prefer these because they don't introduce additional lens surfaces into the optics system, thereby retaining maximum resolution. The disadvantage, however, is a significant loss of light. With the proper lighting, this problem can be overcome.

The least expensive method of close focusing is with diopter lenses that screw (like filters) onto the front of the normal 50mm lens. No light is lost, but there is a minute loss of resolution, especially at the edges. Diopter lenses are available in a set of three lenses: +1, +2, and +4.

A tripod prevents camera movement during the exposure. Extremely light travel tripods are not very good; the heavier type—which no one enjoys drag-

ging around—are best. A cable release will trip the camera's shutter without jarring it; for critical sharpness it is definitely worth using.

If you are photographing butterflies outdoors in the early dawn, you won't need supplemental lighting (unless it is very windy, when using a flash will freeze the butterfly's movement). In the studio or your living room, you will have to use artificial light. Use an electronic flash with daylight film, such as Kodachrome 25 and 64 and the Ektachrome films 64, 200, and 400; the color quality of the light emitted approximates daylight at midday. The primary advantage of using a flash is that you can control the direction of light, and you can light the butterfly from the front, side, or back. The duration of the flash is very brief, between 1/2,000th and 1/50,000th of a second, and if the butterfly moves slightly during this short interval, the wings will not be blurred in the photograph.

The distance from the flash to the sub-

ject determines the lens aperture (which you set by setting the f/stop). By positioning the flash very close to the butterfly, for instance, you will need a small f/stop to obtain a proper exposure. This results in maximum depth of field, producing an image with every detail of the insect as sharp as possible. Conversely, when the strobe unit is placed farther away, a larger aperture must be used to compensate for the diminished intensity of light falling on the subject. The background becomes softer and less defined with the loss of depth of field.

There are, however, disadvantages to using an electronic flash. The primary disadvantage is that you cannot see where shadows and highlights will fall until you have the film developed—the flash duration is much too short for the analysis of lighting and texture. Studio strobes that have modeling lights (some are available for under \$150) solve this problem. They have a small, built-in incandescent bulb that directs light on the subject just as the flash will when it is triggered. You can then arrange the lighting according to your preference.

A second disadvantage of using a flash is that you cannot use your camera's through-the-lens metering system to take a light reading, although there are newer cameras that have a through-the-lens metering system that couples with the flash so that flash intensity is automatically regulated to provide the proper exposure. If your camera does not have this feature, you will have to use a handheld flash meter, the automatic exposure setting on the flash (this is unreliable at distances less than eighteen inches from flash to subject), or the flash distance-f/stop calibrated guide on the side or back of the flash unit. The latter entails measuring the distance from the subject to the flash and then consulting this chart to determine the f/stop.

Some photographers use incandescent lights (sometimes referred to as tungsten illumination) as their main source of illumination. The obvious advantage is that the effects of the lighting can be studied before each shot. The lights can be arranged for the best artistic effect or to make the butterfly look more natural, and you can use the built-in camera meter to determine the exposure.

Incandescent lights should be purchased according to their Kelvin temperature rating and then used with the appropriate film. For example, use Ektachrome 160 with lights producing a color temperature of 3200 degrees Kelvin.

The most significant disadvantage of tungsten illumination is the heat generated by the bulbs. A 250 or 500 watt bulb can cook a butterfly if it is placed too close. Also, the higher temperatures could warm up the insect enough to al-



With a 35mm camera mounted on a bracket, two flash units can be placed on either side of the camera to provide enough illumination to enable you to use small apertures for increased depth of field.

low it to fly away—Lepidoptera can raise their body temperature as much as thirty degrees above the ambient reading by absorbing heat into their body.

If you are photographing outside in breezy weather, you might want to supplement the natural light to give greater depth of field and to allow you to use a fast shutter speed. Some photographers use one flash unit mounted above the end of the lens. The proximity of the flash to the subject floods the area with so much light that you can use a small f/stop. I prefer, however, to use two strobes, one placed on either side of the camera with a double mounting bracket (see photograph) that are synchronized to fire at the same instant. This type of illumination surrounds the small subjects more completely and prevents the picture's background from becoming too dark. In either case, the shutter speed is 1/60th or 1/125th of a second, depending on the camera's flash/sync capability.

It is interesting to note that when using f/22 at 1/125th of a second, the light from the sun becomes irrelevant and does not contribute to the exposure; the exposure is determined solely by the distance from the flash to the subject. The best way to measure the light in this instance is to use a flash meter. If you don't have such a meter, run a test roll of film. Use the strobes on manual mode, not automatic, and vary the distance

from the flash to the butterfly in one-inch increments from four to twenty inches. The slide that is exposed the best will determine your flash-to-subject distance.

It has crossed my mind that a butterfly, peacefully drinking nectar from a flower, must be terrified seeing (especially through its compound eyes!) this awesome camera apparatus attached to an approaching human. Nevertheless, it has been my happy experience to have many of my subjects adopt a wait-and-see attitude.

The insect order Lepidoptera is comprised of approximately 165,000 species of butterflies and moths. Photographing them—not only as adults, but as eggs, larvae, and pupae—can be a life-long odyssey that brings many moments of great pleasure. Studying butterfly biology is intriguing, and appreciating their beauty is uplifting. Indeed, they deserve our respect, our admiration, and our reverence.

James Allen is a professional photographer based on the West Coast. He has taught photography at UCLA and Kent State University and leads photography tours to many parts of the world. He has published many articles in photography magazines. His range of photographic interests include ethnic dance, classic cars, foreign festivals, archaeological sites, photomicrography, and wild life.

Butterfly Organizations

The best way to learn more about where and when to find butterflies is to talk to others who share your interest.

Lorquin Entomological Society. *One of the most active groups of amateur entomologists in the world, with a large number of members interested in butterflies and moths. Meets on the fourth Friday of most months in the Natural History Museum. Annual dues \$3, monthly newsletter. For membership and information contact David G. Marqua, Whittier Narrows Nature Center, 1000 North Durfee Avenue, South El Monte, CA 91733.*

The Lepidopterists' Society. *A worldwide organization (primarily North American) devoted to all aspects of the scientific study of butterflies and moths. Publishes quarterly Journal and an informal News (five times yearly). Annual dues: \$12 for students, \$18 regular. For membership and information, contact Eric H. Metzler, Treasurer, 1241 Kildale Square, North, Columbus, OH 43229. The Pacific Slope Section (the West Coast division of the society) is having its annual meeting June 14 to 16, 1985, in the San Bernardino Mountains. Contact Julian Donahue of the Entomology Section, 213/744-3364, for more information.*

(Continued from page 2)

States; in 1981 the U.S. Department of Agriculture could locate only 1,000. In fact, it is estimated that fewer than 20 percent of the vegetable and fruit types of a century ago still survive.

It's tempting to say that these "heirloom" plants were probably not as fine as those we have today. However, whatever we are gaining in ease of harvest, uniform ripening time and size, and adaptation to chemical fertilizers, we are losing in the gene resources that those unusual plants stored. With a variety of plants being lost irretrievably, we no longer have a reservoir of genetic diversity to provide us with disease resistance. We are also losing the aesthetic delights of tasting different kinds of beans or apples or herbs.

However, the federal government, with the National Plant Germplasm System and National Seed Storage Laboratory, and individuals are actively involved in saving unusual heirloom varieties of crop plants. Private organizations have been springing up to exchange seeds and to preserve any odd varieties.

Unfortunately, the banking system is in deep trouble because there is at this time no coordinated federal program to bring together the diverse groups under one aegis and no standardization of goals and procedures.

In addition, this dilemma is compounded by the fact that the seeds of crop plants cannot merely be stored in banks. Because the average storage life for a seed is thirty years, these seeds must regularly be grown and carefully pollinated by hand. It is a time-consuming and perhaps an almost impossible task.

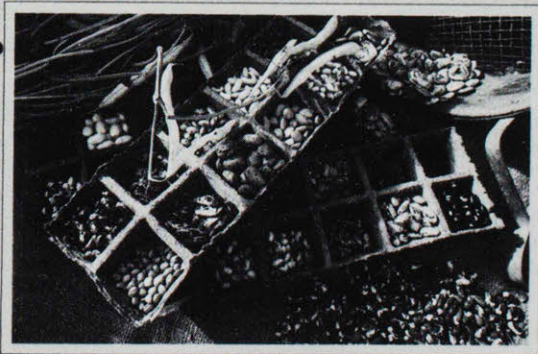
Carolyn Jabs covers all this and more in her timely and remarkably truthful book. The joy of reading *The Heirloom Gardener* is to discover what remains and how you can locate collections and collectors. Jabs discusses some truly remarkable plants, and the lively reading makes you want to become involved immediately. The book deals with home gardening, hybridizing, cleaning seed, flailing and winnowing (how many children can define "flail" or "winnow"?), as well as practical advice on obtaining and cultivating heirloom varieties. The book

has wondrous appendices on seed exchanges, seed companies, living historical farms and museums, sources for books and catalogues, federal repositories, and a fine bibliography.

I must profess great admiration for this book, as it reflects a scholarly mind, a passion for the subject, a lively style, and a critical bent. In an era of expensive novels of little content, a book of substance is more than welcome. You will want to keep this volume for reference.

WILLIAM A. EMBODEN, Ph.D.
Research Associate, Botany

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